POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

VOL. XXVII CHICAGO, MARCH 1, 1923 No. 5

Meeting De Luxe Service Requirements

DESCRIBING THE MECHANICAL FEATURES OF THE LARGEST OFFICE BUILDING OF ITS KIND IN THE WORLD. BY C. C. WILCOX

BECAUSE OF the rapid growth of the General Motors Corporation and its almost endless variety of interests during the last decade, it was apparent as early as 1917 that some provision would soon have to be made for the housing of the general offices, which were then inconveniently scattered throughout the business districts of the city of Detroit. To overcome the annoyance of this condition and to provide a home for the corporation that would adequately take care of its future growth, and be in keeping with the standard of products manufactured, the idea of the General Motors Building was conceived. On account of its unusual proportions, unique features and the wide publicity it has had, it is not strange that many of the details of the project have been incorrectly stated and even its real purpose misunderstood. The purpose of this description is to correct the misinformation and describe some of the more interesting features of the mechanical equipment.

Occupying an entire city block approximately 365 by 522 ft., one block distant from the intersection of two of the city's principal thoroughfares, Grand Boulevard and Woodward Ave., the building is located almost at the exact geographical center of the city, in virtually a residential district about 2½ mi. north of the business center. A portion of the building not at present required by the General Motors Corporation is rented to high class tenants on short term leases. The absence

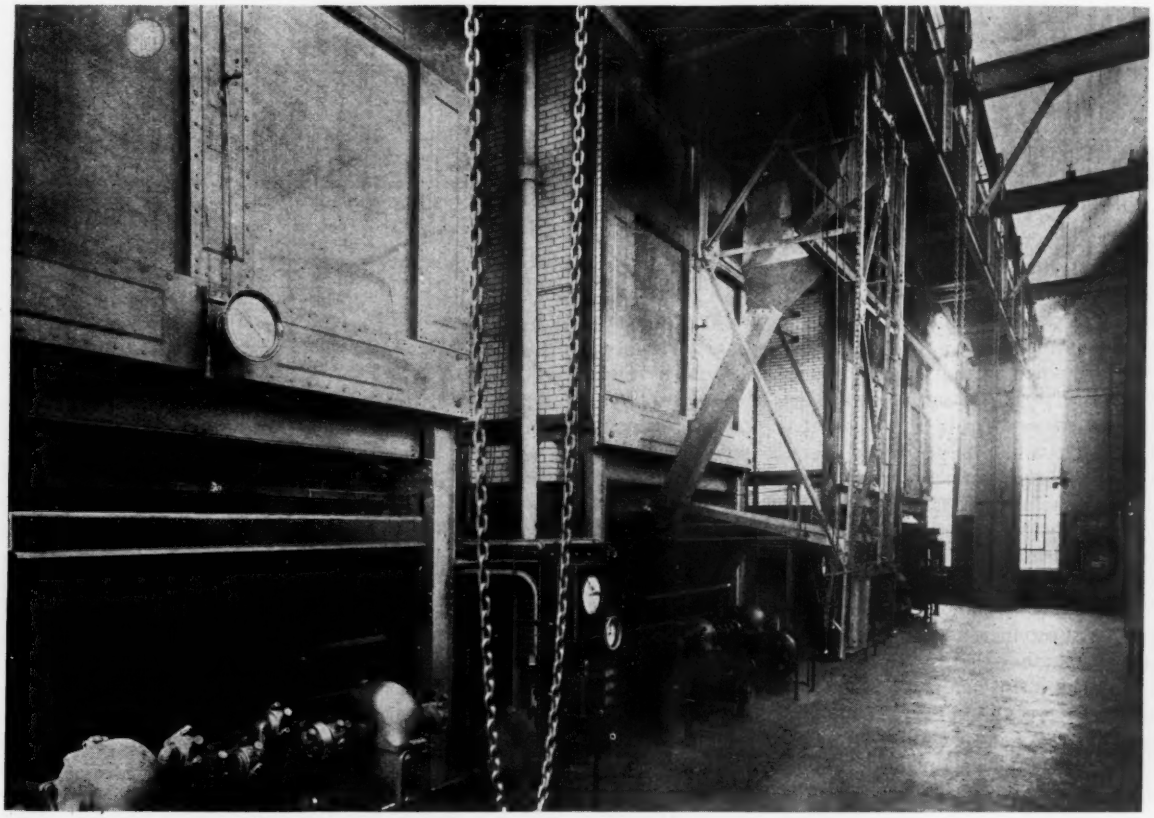


FIG. 1. FIRING AISLE, LOOKING EAST. GENERAL MOTORS BLDG. PLANT

of noise and dirt, the parking facilities in the vicinity of the building and its proximity to a high grade residential district, add to its popularity among the class of tenants solicited. When the building is completely filled there will be, on the basis of the present density, a population of about 6000 persons, in addition to the operating force of about 400, including administration, engineering and accounting forces, power plant employes, plumbers and steamfitters, electricians, carpenters, masons, painters, elevator operators and mechanics, watchmen, service men and janitors. When it is recalled that the population served is made up almost wholly of a very discrim-

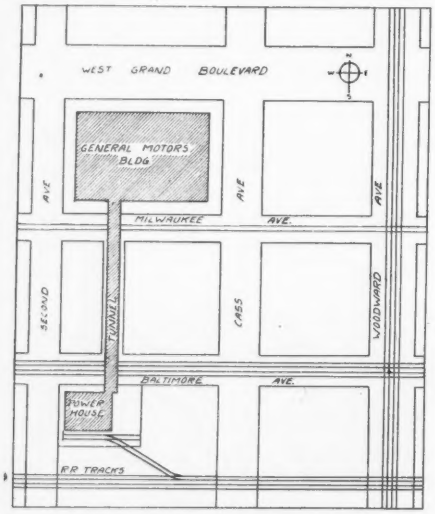


FIG. 2. STRATEGIC LOCATION ADJACENT DETROIT'S MOST IMPORTANT ARTERIES OF TRANSPORTATION

inating class, accustomed to de luxe service in every particular, and when it is recalled that the service rendered is as diversified as that on shipboard, including business office service, hotel accommodations, and recreational features, it can readily be seen that the most careful attention must be paid to the selection and installation of mechanical equipment to provide this service. While certain features of the equipment may appear to be rather elaborate, the ideas of flexibility, continuity of service, efficient operation, as well as attractive appearance have been consistently followed.

In Fig. 2 is shown a general plan of the property. Two features in connection with the building are striking: First, that the building power plant is not located in the basement nor sub-basement of the building, but rather several hundred feet distant; second, that the power plant is adjacent to a railroad and has its own siding. This keeps the noise and dust away from the office building and adds materially to the convenience in operating the plant. The basement of the laboratory building and the basement of the power plant are on the same level, so that trucking between the two points can be easily done through the inter-connecting tunnel, 8 by 11, which has a clear gangway about 8 by 8 ft., the piping being supported on pipe racks at one side. The electric ducts between the power plant and the office building are located just outside of and parallel to the main tunnel—4 in. fiber conduit construction laid in concrete.

Coal Handling

FIGURE 3 shows the general arrangement of coal receiving and handling facilities. Coal may be received either in hopper bottom or gondola cars, preferably the former. If received in hopper bottom cars it is unloaded directly into the track hopper or a limited amount may be dumped through the trestle into storage. If received in gondola cars, it is unloaded by locomotive crane into either the track hopper for power house delivery or into storage, as required. Coal may also be reclaimed from storage by the locomotive crane. The amount of coal handled would not justify the purchase of a locomotive crane for this purpose alone but was moved to its present location after having been purchased and used for material handling during the construction period. It is a McMyler Interstate Standard, type B, locomotive crane with 50-ft. boom and 45-cu. ft., type R, clamshell bucket and may at some future date be replaced by a less expensive equipment.

Moving of cars on the company's siding is done by a Stephens-Adamson car puller located at the east end of the siding and operating through a snatch block anchored to the west end of the siding to enable cars to be moved in either direction. The balance of the coal handling equipment was manufactured by the Stephens-

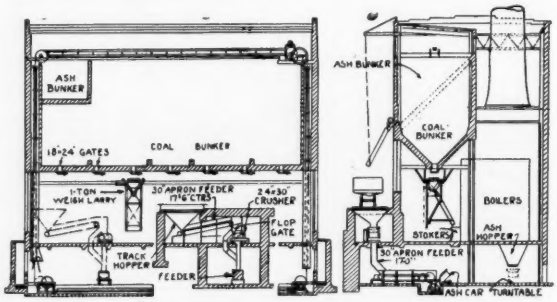


FIG. 3. COAL AND ASH HANDLING EQUIPMENT

Adamson Mfg. Co. and consists of a track hopper, crusher and pivoted bucket conveyor, as shown in Fig. 3. The track hopper measures 12 by 12 ft. at the track level and discharges onto the receiving end of a steel apron feeder 30 in. wide by 17 ft. 6 in. center which discharges into the crusher. The crusher is of the toggle spring release type, double roll, and is provided with bypass and flop gate so that slack coal need not be fed through the crusher rolls. The crushed coal is discharged from the crusher or bypass into a tail spout feeding the receiving end of a cross conveyor of the apron type 30 in. wide by 17-ft. centers. This cross conveyor discharges the coal onto the lower run of the pivoted bucket conveyor in the basement of the boiler room.

Steel is used in the construction of the track hopper, which, together with the apron feeder and coal crusher, is located in a closed room on the same level and adjacent to the boiler room. The crusher room is provided with an ample amount of steam radiation so that in extremely cold weather it is possible to prevent coal from freezing up in the track hopper.

Both upper and lower horizontal runs of the pivoted bucket conveyor are 92 ft. long, and the vertical runs, 62 ft. The buckets are of the roll lip type of malleable iron 24 in. by 18 in. The vertical runs of the conveyor

are completely housed within a steel casing carrying guide angles the entire height and the lower run is located in a concrete trench covered over by checkered steel plate. The upper run of the conveyor is located above the coal bunker, one end of which is partitioned off for the ash bunker, and the automatic tripper is so arranged that it can discharge the buckets into the coal bunker or when carrying ash can be discharged into the ash bunker.

There are three motors required to drive the complete coal handling equipment, a 15-hp. unit driving the pivoted bucket conveyor and located at the upper west end of the pivoted bucket conveyor, a 5-hp., driving the cross conveyor and a 30-hp., driving the crusher motor which operates the apron feeder as well.

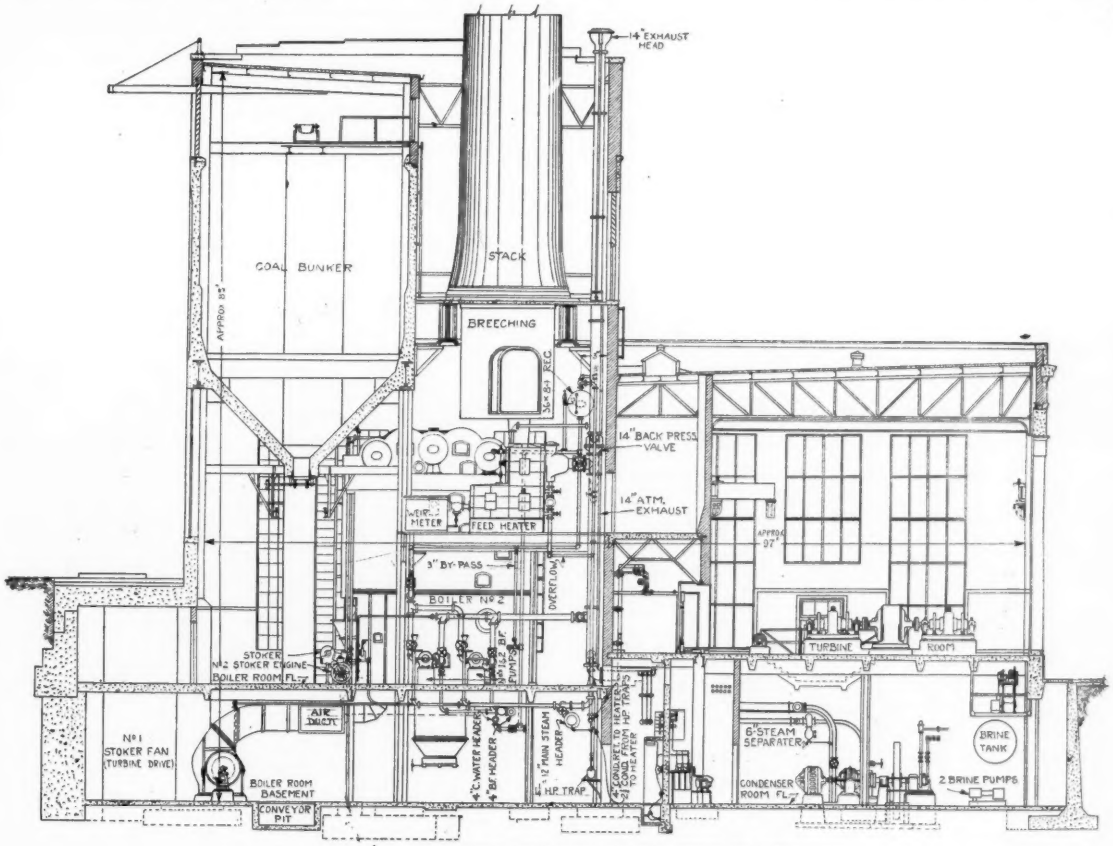


FIG. 4. CROSS SECTION THROUGH POWER PLANT

These are all Allis-Chalmers 40 deg. continuous duty squirrel cage induction motors. They are provided with Allis-Chalmers type N-1 potential starters and these starters are so connected that the main conveyor has to be started first and in the event that this conveyor shuts down due to open circuit on the motor or to overload the de-energizing of the motor leads drops out of the starter on the cross conveyor motor and this in turn stops the crusher motor. This sequence of connections prevents the jamming of the conveyor in the event the crusher were passing coal with either one of the conveyors stopped. This condition actually happened before the starters were connected in this manner.

In addition to the foregoing precautions, a series control circuit is run to a number of different points where men are liable to work around the crusher and conveyor and at these points are located switches by which the entire apparatus can be shut down and prevented from being started up until all of these switches are again closed. This renders it possible to work on the conveyor with safety at any point and also to shut it down quickly in case trouble develops. There is also located a safety switch on the lower leg of the pivoted bucket conveyor so that in the event any bucket fails to right itself properly before entering the lower run, the conveyor motor is stopped. The horizontal run of the pivoted bucket conveyor is provided with heavy cast iron chairs placed 5 ft. apart and lubrication is effected by two grease cups on each bucket and by internal lubrication of the chain wheels. The tripper is moved manually by a winch located near the operating motor above the coal bunkers. The crushing and conveying capacity of the entire outfit is rated at 50 T. per hr. A removable louvre above the coal bunkers and an overhead beam projecting through the opening is arranged so that in the event any of the apparatus above the bunkers has to be replaced or taken down for repairs it can be handled with dispatch. The control for all of the coal handling apparatus is located in the center of the boiler room on the opposite side of the firing aisle from the boilers. This renders the operation of the outfit more convenient and simplifies the wiring which is brought to a distribution switchboard in a room located immediately in the rear of these controllers. The car puller is controlled from this switchboard and there is space left for a motor driven boiler feed pump which is not yet installed.

Coal bunkers, located above the firing aisle, are of re-inforced concrete construction hoppered-down to a straight keel bottom in which are located the coal gates—seven in number. All of these are equipped with a special housing to eliminate dust when dry coal is being drawn from the gates. The coal bunkers have a capacity of approximately 1300 T. of coal. The probable annual consumption of coal in the event steam turbines are installed and all of the current used at the property is generated in the power plant and after the office building is entirely completed will be about 14,000 T. per yr.

boilers in operation which is very desirable for the testing of coal and for removal of coal from any place in the bunker where hot spots might develop. All coal burned is recorded on the weigh larry—the results of which form the basis of the daily power plant operating report.

Ash and refuse is dumped from stokers into Dunbar Allen cast-iron, brick-lined ash hoppers extending the entire width of the boiler and in the bottom of which are provided two roller bearing gates for the removal of ash. The ash is drawn from these hoppers into ash

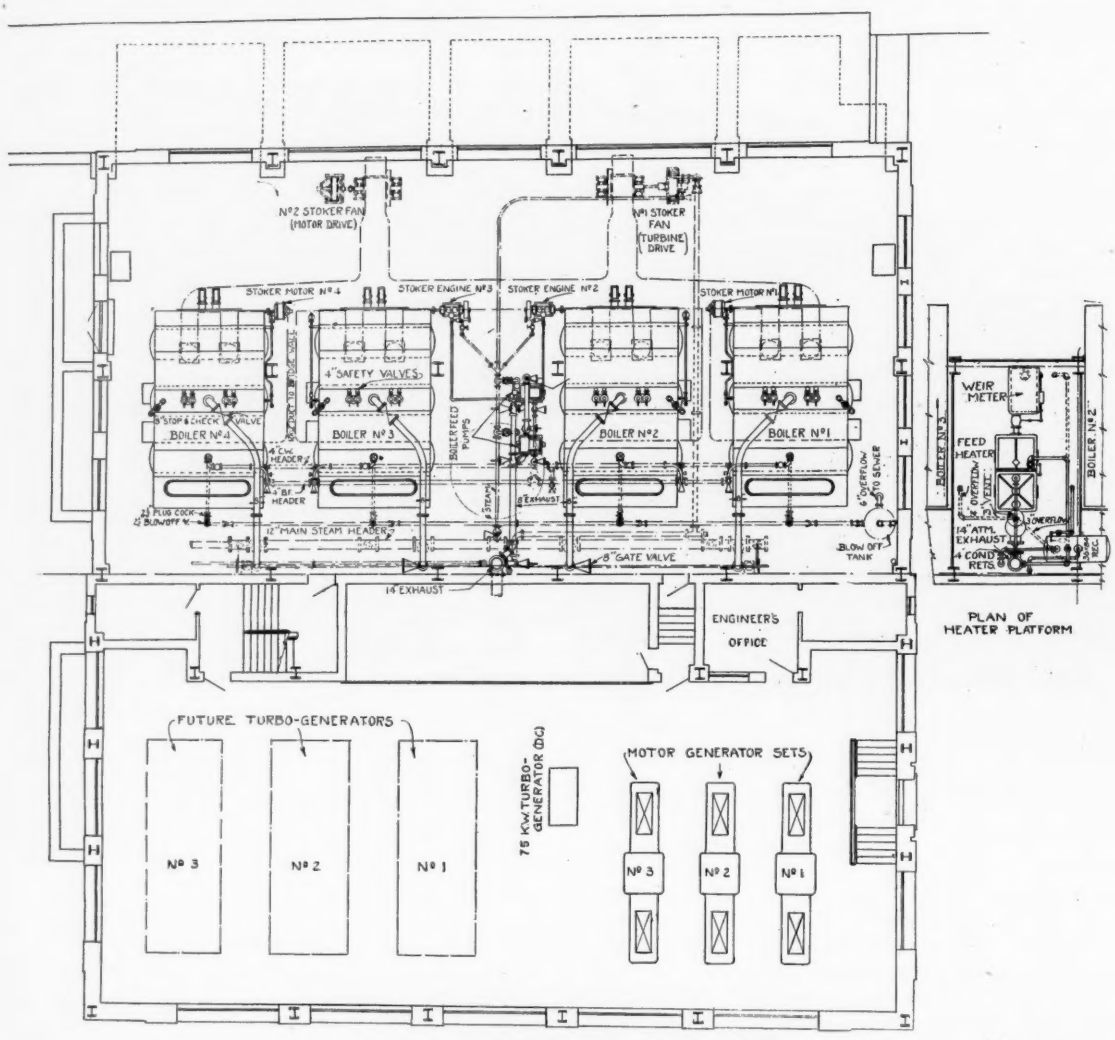


FIG. 5. FIRST FLOOR PLAN OF POWER PLANT

It is seen from this that the bunker capacity is approximately equal to 30 days' supply in the severe winter weather so that if the winter season is entered with the bunkers full and if they are kept full or nearly so, the property is entirely independent of irregularities in shipment of coal and is even independent of breakdown in the coal handling equipment itself, except for the inconvenience which would be incurred in case the weighing larry itself should be out of commission at the same time.

Coal can be drawn from any one of the seven coal gates into the weigh larry and served to any one of the

buggies holding 1200 lb. of dry ash. These buggies are pushed by hand to a point in the center of the lower run of the pivoted bucket conveyor over which is placed a strong grating having steel bars placed at about 8-in. center. The ash is dumped onto this and the larger clinkers that will not go through are broken up with a sledge hammer.

With the exception of the ash delivery point in the center of the run the entire lower run of the pivoted bucket conveyor which is located in a concrete trench 3 ft. deep by 6 ft. wide, is covered with checkered floor plate. A great deal of attention has been paid to the

elimination of as much dust as possible in the boiler room. In this connection, it was found that the coal leaving the crusher had such a high velocity that considerable dust was produced at that point which found its way out through the crevices of the cross conveyor. A counter-weighted gate was put in the tail spout of the crusher which assisted in slowing up the coal and therefore, more nearly filling the chute with a consequent elimination of dust. It was also found desirable to house completely the discharge end of the cross conveyor and the bucket conveyor adjacent to it in order to confine the dust forming at that point. A special hopper was also secured in the weigh larry hopper (and the scale corrected therefor), which reduced the amount of clearance between the weigh larry and the coal bunker gate which practically eliminates the dust at this point. The stoker hoppers were also provided with specially designed covers to prevent the escape of dust into the room at the time the hoppers are being charged.

To prevent the spilling of coal on the boiler room floor between boilers a counter-weighted gate was placed on the end of the delivery tube from the weigh larry.

FIG. 6. THE GENERAL MOTORS BUILDING, DETROIT

These refinements of the apparatus to eliminate dust have been comparatively inexpensive and at the same time keep down the cost of maintaining the plant in a presentable condition.

Boilers

Four boilers are provided. These are Stirling class 0-20, 500 hp., A. S. M. E. Standard for 199 lb. working pressure, with the mud drums set up 7 ft. 6 in. from the floor line. This gives approximately 10 ft. from the grate to the nearest heating surface and the volume of combustion space is 1200 cu. ft. in front of the front bank of tubes. The settings are insulated with Sil-O-Cel brick throughout and the top of the drums are covered over with a layer of Sil-O-Cel brick protected by a coating of cement. The steel stack which removes the products of combustion is also lined to a distance of 60 ft. with 4½ in. of Sil-O-Cel brick.

While the object of this insulation in the stack was to protect the steel from excessive heat and consequent expansion and possible warping of the plates, it also materially increased the draft of the stack. It prevented erosion and infiltration of cold air and protected the steel from corrosion from the flue gases. Radial brick would have prevented corrosion but has no insulating value. They would have had six times greater weight and extra steel would have been required in the supports.

The Sil-O-Cel brick were laid up in regular ring courses with tight joints of Holdtite insulating cement. All brick were cemented solidly to the stack with special Holdtite sticking cement, and were plastered smoothly with Holdtite refractory cement.

FIG. 7. THE POWER PLANT IS SEVERAL HUNDRED FEET FROM THE BUILDING

Insulation of the stack as well as the two large breechings and smoke drum with Sil-O-Cel brick was done by the Holdtite Insulation Co., Inc.

In each boiler the top half of the front wall is supported on a horizontal beam so that the lower portion of this wall, subjected to the highest temperature, can be removed without disturbing the upper part. The exterior of the settings are laid up with white glazed brick. This class of brick serves the double purpose of rendering the settings practically impervious to air and at the same time, adding greatly to the appearance of the boiler room. The blowoff valves are made up of the Homestead-Hovalco combination. The stop and check valves are the Pittsburgh Valve Foundry & Construction Co.'s and the feed is controlled by Copes regulators.

Each boiler is equipped with a five-retort Westinghouse underfeed stoker with hand dump. Air blast is fed to these stokers by a 36 by 60 in. duct running underneath the boiler room floor which receives its air from two Buffalo conoidal fans; one driven by a 1160 r.p.m., three-phase induction motor, the other by a Westinghouse steam turbine. The speed of the stoker engines and the pressure of air under the stokers is controlled by Ruggles-Klingemann regulators. The air pressure control is effected by balanced louvre dampers located in the discharge of the fans.

All stoker plungers are 9 in. in diameter by 12 in. stroke and there are 17 tuyeres. Two of the stokers are driven by Westinghouse adjustable speed 12 hp. direct current motors and two are driven by single-acting Westinghouse 4½ by 5 in. steam engines. The speed range on the stoker drive is from 90 per cent to 250 per cent rating. The ratio of speed shaft to stoker shaft is 352

to 1, and the minimum and maximum desirable speeds for the engine are 114 and 300 respectively, which makes the corresponding revolutions of the stoker crank shaft per hour 19.4 and 54. The foregoing is based on an evaporation of 8.5 lb. water per lb of coal and a factor of evaporation of 1.04.

On account of the service being purely heating at the present time, no superheaters have been installed. Diamond soot blowers are used with Hancock valves and hand control.

In front of each boiler at one side is located a slate instrument board upon which is mounted a type D-25 Bailey boiler meter, a triplex Precision Instrument Co. draft gage and a Uehling CO_2 recorder. On the gage board for the motor driven stokers the motor controller is also located. This arrangement and combination of instruments seems to be very satisfactory, inasmuch as

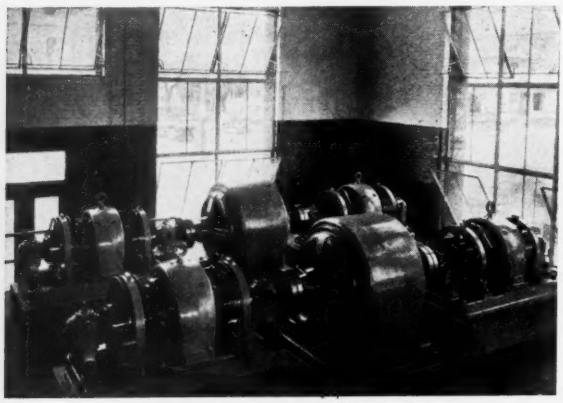


FIG. 8. MOTOR GENERATOR SETS FOR ELEVATOR OPERATION

it is not necessary for the operator to go to the side of the boiler or to some other inconvenient point to observe the results of any changes he has made in his draft or air pressure. The arrangement and selection of instruments have been made primarily for the guidance of the fireman.

Boiler feed water is measured by a Bailey type F-4 fluid meter having provision for two weirs. This meter records the feed water temperature on the same chart with the rate of water flow.

In the design of the mechanical equipment of the property it was recognized that a great amount of very useful information could be obtained by a fairly complete system of metering the various classes of service furnished. With this in mind, meters have been installed to give a complete distribution of all electric energy, hot water, cold water, drinking water, refrigerated brine, gas, etc. The writer has never before known of an office building equipped to furnish this information completely and with the desired degree of accuracy. Worthington piston type meters are used for the hot water and disk meters for cold water, these being arranged in every case so that their accuracy can be periodically checked.

Distribution of steam between the laboratory and the various uses in the main office building is determined by General Electric F-3 steam flow meters. Each meter except the one measuring low pressure steam to the main building is provided with two flow nozzles one in the straight through line and a smaller one in a bypass, in order to get readable deflections at all seasons of the year. High pressure drip is accomplished by Strong, Carlisle & Hammond bucket trap discharging into the hot well. The total amount of condensate from all sources returned from the office building to the power plant is measured by a Central Station Steam Company's rotating meter. This meter is located on the roof of the power house beneath a surge tank into which all the condensate is delivered. A hot well system is arranged in the plant from which the various miscellaneous clear water drips are received and metered. From this point these drips are pumped to the feed water heater.

All high pressure valves and fittings are built for 250 lb. pressure and the pipe joints 4 in. and over are Van Stone. All steam and water valves throughout the property except certain specialties such as radiation valves, etc., are Lunkenheimer.

Future Provision for Electric Generation

Space has been left in the turbine room for the installation of steam turbines for the future generation of all the electric requirements of the property, and the capacity and maximum pressure of boilers, as well as all other features of the plant, have been worked out with this in mind. Electric energy is, at the present time, being purchased from the Detroit Edison Co.—a portion of which is DC and a portion AC. As soon as the office building and laboratory are more nearly filled to capacity steam turbine equipment will undoubtedly be installed as the characteristics of the load will then be very well known and it will be possible to make a careful selection of the equipment best adapted to the requirements.

Electric energy from the Detroit Edison Co. is brought into the basement of the turbine room at a potential of 4600 v. and distributed through the switchboard, which is remote electrically controlled. The cell structure is located in the basement and there is provision made for three future turbo-generators. The Detroit Edison current is now distributed through two of the cells designed for the future turbines. The main oil switches are Westinghouse B-4, 600-amp., and operate through 500-amp. General Device & Fittings Co. disconnect switches onto a double bus. Three of these oil switches are generator switches, as above mentioned, and the balance are feeder switches for power house or main building circuits.

Refrigerating Equipment

Refrigerating apparatus, which is of the CO_2 type, was built by the Automatic Carbonic Machine Co. and consists of two 40-T. machines, based on 15-deg. brine and 70-deg. circulating water. This equipment is located in the condenser room at the power house. The compressors are double-acting 5½-in. by 16-in. stroke; diameter of rod, 2¼ in. The compressors show rated capacity, under contract conditions, at 86 r.p.m. One compressor is driven by a 60-hp. slip-ring induction motor, 720 r.p.m., operating through a Poole reduction gear ratio 8 to 1. The other compressor is driven by a 12 in. by 24 in. Hamilton Corliss engine running at 86 r.p.m. controlled by fly ball governor and Hamilton automatic engine stop. Each machine is provided with a 9 ft., 7000-lb. flywheel.

Shell type CO_2 condensers are provided. These are arranged in two groups of four each. The 1-in. water

inlet is at the bottom and the outlet at the top. The size of these condensers is 6 ft. high by 9 in. in diameter. The circulating water passes through the inside of ¾-in. copper coils and the CO_2 gas is on the outside of these coils. The entire combination is tested to 3000 lb. pressure. Each condenser has 42.2 sq. ft. of cooling surface, a total of eight condensers being installed. On account of the clear circulating water available in Detroit, this class of condenser was selected on account of the small number of joints in the CO_2 system with a consequent reduction of gas leakage. It is possible to group these condensers and brine coolers quite close together and still have them accessible. The brine coolers are exact duplicates of the condensers and are arranged in two groups of eight each and the gas and liquor piping is so

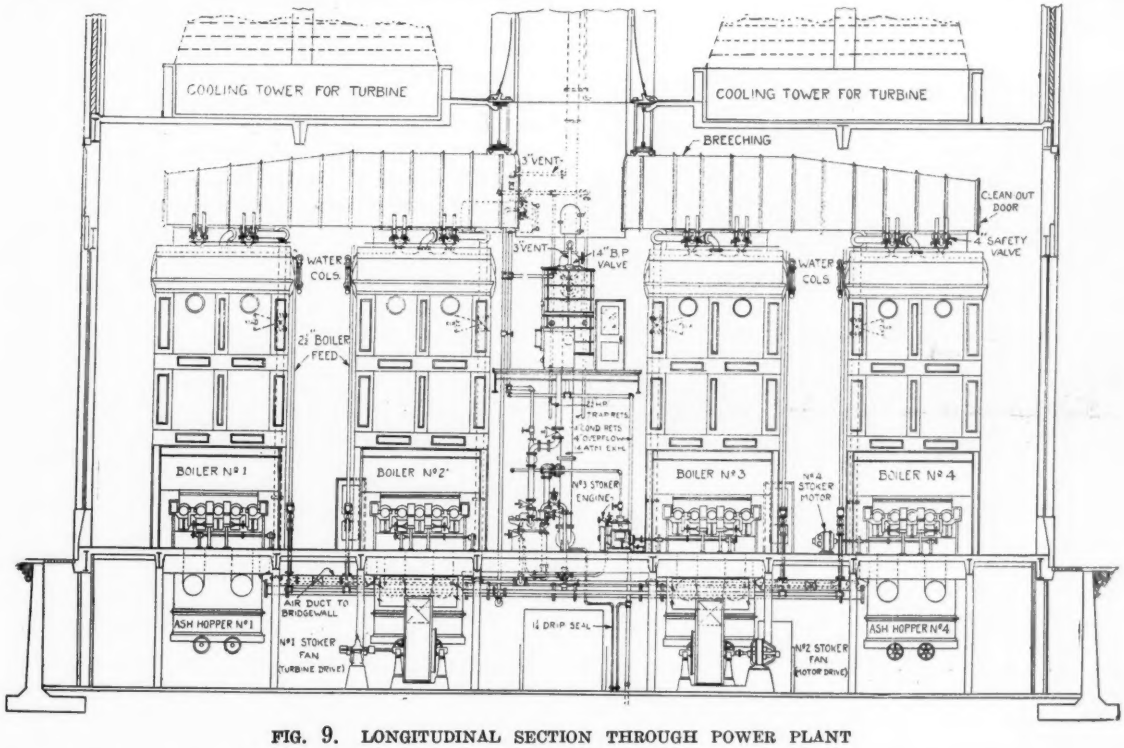


FIG. 9. LONGITUDINAL SECTION THROUGH POWER PLANT

arranged that either group of condensers and brine coolers may be used with either one of the compressors. In addition to this, it is possible to remove any one of the condensers or brine coolers from the group without disturbing the connections to the others. The pressure relation valves, of which there is one to each pair of brine coolers, are located in the aisle between the condensers and brine coolers.

All cold gas, liquor and brine lines are covered with cork insulation and the brine coolers with moulded Gimco covering. A brine circulating system through the tunnel to the main building serves the ice making equipment in the basement of the laboratory, the drinking water in the sub-basement, the concession stores in the main lobby and the kitchen and cafeteria on the fifteenth floor.

Two brine circulating pumps located in the basement of the power house provide circulation. These pumps are Allis-Chalmers, 200-g.p.m., motor driven, centrifugal, operated by a 25-hp. slip-ring induction motor at 1740 r.p.m. The brine storage tank, located above the pump, is 5 ft. in diameter by 18 ft. long and covered with 6 in. of cork insulation. A Gould triplex pump, 2¼ by 4 in., driven by a 2-hp., 1150-r.p.m. induction motor, serves for charging brine into the system, the brine being mixed and agitated in a mixing tank located near the brine storage tank. The brine circulating pumps are designed to operate against a head of 185 ft., which is made necessary on account of the extreme length of line served. The metering of the refrigeration in brine circulated to any service is accomplished by a Westinghouse heater element in connection with the temperature rise of brine produced.

Ice making equipment, which was installed to manufacture ice for use in the cafeteria and in drinking water coolers, consists of a freezing tank of 3/16-in. steel, dimensions 17 ft. 6 in. by 6 ft. 6 in. by 3 ft., and contains sixteen 100-lb. ice cans. The outfit is equipped with a Burns hand puller and dumping device. The primary brine coils in the ice tank consist of 1200 ft. of 1¼-in. pipe. The outside of the tank is covered with 6 in. of cork insulation, with wooden top. The secondary brine is circulated by a propeller type agitator and the agitating air is furnished by Connorsville blower, 517-B, maximum speed 1200 r.p.m. The harvested ice passes through an automatic door into an ice storage room, 12 ft. by 13 ft. by 6 ft. inside dimensions, cooled by primary brine circulated through sections of wall type radiators and the room is insulated by 8-in. cork insulation. The temperature is maintained constant by a thermostatic valve on the brine line and a recording thermometer is installed for purposes of record.

Drinking Water Sterilization

For the purpose of sterilizing the drinking water a drinking water sterilization system was installed with a

capacity of 1000 gal. per hr. The water is taken from the low pressure city system in the sub-basement—is first passed through the electric coagulator and from there to the coagulation chamber in the sterilizer unit, then through one of the two filtering chambers and from there to the Ozone sterilizer. The level of the water in the Ozone sterilizer is maintained constant by a float valve interlocked electrically with the discharge valve from the filters, so that in case of failure of the electric supply for purpose of sterilization these valves will not open, so that it is impossible to pass water through the units without sterilizing.

From the Ozone sterilizer the water passes through a drinking water cooler which is a galvanized cylindrical tank 6 ft. in diameter by 7 ft. high in which are placed 1150 linear feet of 1¼-in. galvanized cooling coils circulating brine under thermostatic control. The brine

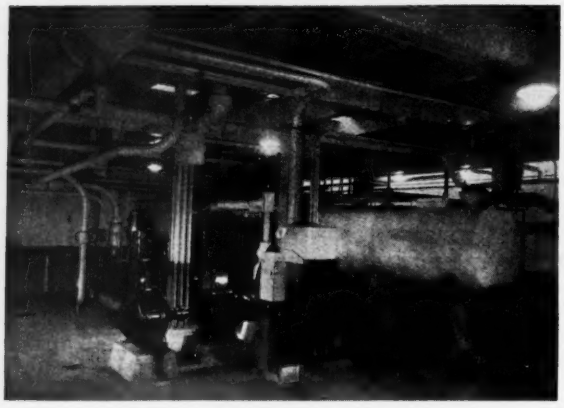


FIG. 10. REFRIGERATING APPARATUS IN THE BASEMENT OF POWER PLANT

passes through the coils and the drinking water is on the outside; hence, with this arrangement no damage would be done to the coils in case of failure of the thermostatic valve and freezing of the drinking water. The tank is insulated with 4 in. of cork insulation on the bottom and 6 in. of granulated cork on the sides. The outside of the tank is finished with beaded ceiling. The level of water in the drinking water cooler and the Ozone sterilizer is the same, so that as water is used out of the system and the level falls in the drinking water cooler, which is a vented tank, the level falls in the Ozone sterilizer which automatically opens up the electrically operated valve allowing water to enter through the coagulator, filter and into the Ozone sterilizer—thus restoring the level in the sterilizer and drinking water cooler.

In the main building there are four drinking water fountains on each floor, located at convenient points in the corridors and the water is circulated through the system by a Deming 4 by 4-in. triplex pump operating at present at 31 r.p.m., which is approximately one-half the speed at which the pump will be used when the building is completely occupied and all of the drinking water system is connected. A 1-in. centrifugal pump, built by the Western Pump Co., is used as a spare in case of accident to the main pump. The plunger pump is ordinarily used on account of its higher efficiency which is desirable at this point.

In the suction line leading to these two pumps is an R. U. V. sterilizer having a capacity of 1000 gal. per hr. The current for the violet-ray lamp is furnished by a motor generator set in order to get good regulation. The purpose of putting the R. U. V. sterilizer in this location is two-fold. First, the greatest life can be obtained from the lamp as it is not started and stopped very often; consequently, if it were placed on the inlet line to the Ozone sterilizer, it would only be furnished with an interrupted supply of water and would consequently heat up and be damaged during periods when no water was being used. When used on the suction line to the circulating pump, however, the temperature is kept down, due to the circulation of water even though no water is being drawn from the system, and when the pump is shut down during the night period, a thermo-syphon cooling is effected by connection to the drinking water cooler. Again, by putting the sterilizer in the suction of the circulating water pump, it eliminated the possibility of incubation going on unchecked in the circulating system even though the water has previously been adequately sterilized in passing through the coagulator, the filters, and the Ozone sterilizer. While the chance of incubation proceeding at this temperature is not thought to be very serious, the Ozone sterilizer was installed at this point and the results obtained so far indicate that a water of zero bacteria count can be regularly maintained.

Water Systems

Only two cold water pressures are used: the city water pressure which is used in the sub-basement, basement and first floor, and the house tank pressure which is used for all hot and cold water above the first floor. All of the high pressure house water is handled by two Allis-Chalmers centrifugal pumps. These are 300-g.p.m. pumps designed for 250 ft. head at 1750 r.p.m. These are direct connected to 40-hp., three-phase induction motors controlled by a float located in the house tank, operating through two E. C. & M. Co. compensators, size No. 1. The float in one of the house tanks is set above that in the other, so that one of the pumps will start upon the water-level reaching the higher float and the other pump when the lower level is reached. The switching equipment is so arranged that this sequence can be periodically reversed. At the present time, temporary arrangements have been made so that circulating water from the refrigerating condensers is discharged into one of the swimming pools, which is not in use, and stored there until required by the cold water house system. The suction line of the house pump is so arranged that it can draw water either from the city system or from the swimming pool.

Permanent arrangements have been made for a water interchange line between the power plant and the main building which will enable the cooling tower basins, located on the roof of the power house, to be used instead of the swimming pool for the purpose of storing water ejected by the refrigerating condensers. A third house pump of small capacity is installed in the power house which will make it possible to inject the refrigerating condenser water directly into the house high pressure system. This third pump is controlled by one of the float valves in the present house tanks.

Arrangements, of course, are being made so that in event the house tanks are full and the cooling tower

basins are also full, this water will run to the sewer. Present indications, however, are that this will happen seldom or never. As stated before, the house tanks are two in number and are located in the pent house. They are 10 ft. in diameter by 8 ft. high and are provided with over-flow. A Bristol graphic alarm and indicator are installed in the sub-basement, so that the machine room operators will know the level of the water in the tank and will be warned of approaching low level in the case of open circuit or failure of the float switches to operate.

Make-up to the hot water house system is taken from the high pressure cold water system and the heating is effected by two storage type Whitlock coil heaters. These heaters have a storage capacity of approximately 900 gal. each and have a heating capacity of 2500 gal. per hr. from 50 to 180 deg. when supplied with 20 lb. steam pressure. The heating element is arranged to be withdrawn from one end of the heater with a minimum disturbance of piping connections. Circulation in the hot water system is furnished by two 2-in. type "S" Allis-Chalmers centrifugal pumps—75 g.p.m., designed for 50 ft. head operating at 1750 r.p.m. These are driven by a 5-hp. induction motor, controlled by hand-operated starting switch, giving service as the requirements demand. The make-up to the hot water circulating system can pass straight into the system or can be carried through an economizer located in the return condensate line from the main building. Hot water meters are placed to give both the make-up and the total circulation from the Whitlock heaters.

Fire standpipes, one in each of the four pipe shafts, provide for four hose connections on each floor of the main building. This is a wet system, the pressure being supplied by an Allis-Chalmers 6-in., 1000-g.p.m., centrifugal pump, designed for 231 ft. head at 1750 r.p.m., located in the sub-basement. This pump discharges directly into a high pressure tank and has an automatic pressure control by a Cutler Hammer automatic starter mounted in a splash-proof cabinet. The pump is driven by a 100-hp., three-phase induction motor.

Steam for Heating

Steam for heating at the present time is transmitted from the power plant to the basement of the laboratory at 125 lb. pressure where it is reduced to the pressure in the heating mains, about 5 lb., through a Foster type "G" reducing valve and a Fisher reducing valve. The high pressure line is 8-in. Van Stone and the low pressure is a 20-in. line which branches in the basement of the main building into two 14-in. risers going up pipe shafts Nos. 2 and 3. These risers continue to the top of the building where they branch out in a pipe space within the roof tresses for down distribution in the various steam drop legs, one of which is located at every other pilaster around the entire periphery of the building. These are valved off in the pipe space above the fifteenth floor and the return condensate is picked up on the way down, passes through an econozimer and is collected into a condensate receiver in the sub-basement. This receiver is provided with two float controlled centrifugal pumps with automatic panel and arrangements for reversing the sequence of starting, and from this point is pumped with all other condensate from the main building and laboratory back to a receiving tank located on the roof of the power house. This receiving tank discharges to a Central Station Steam Co. condensate meter into the feed water heater. The radiators are swung from side wall brackets and are controlled by the Detroit Lubricator Co.'s packless valve and a Bishop-Babcock Multiflex radiator trap. At the present time, the direct radiation connected amounts to 154,294 sq. ft. and in addition to this, there is the indirect radiation required for heating the first floor and basement. The total glass area, including main building and laboratory, is 213,177 sq. ft.; wall area, 319,600; door area, 1180; roof, 116,925; skylight area, 13,792; cubic feet of contents inside measurement, 16,313,016; inside floor area, 1,337,764. The accompanying table gives a list of the heating and ventilating fans and their characteristics. The fans are all Bayley Plexiform equipped with ball bearings and wherever possible they are driven through Poole reduction gears by Allis-Chalmers motors. The Webster type "A" air washer was selected for the

LIST OF HEATING AND VENTILATING FANS AND THEIR CHARACTERISTICS

						FAN			MOTOR		
No.	Location	Service	Capacity	Static	Speed	Drive	Ratio	H.P.	Type	Syn.Speed	Load Speed
#1	Mezzanine #1??	Auditorium Supply	26,000	1-1/8	377	Poole	6.16:1	15	SD	1200	1150
#2	Mezzanine #1??	Auditorium Exhaust	22,000	3/4	301	Poole	4.27:1	7-1/2	SD	900	840
#3	Auditorium Roof	Auditorium Exhaust	15,000	1/4	415	Direct		5	SD	450	415
#4	Auditorium Roof	Auditorium Exhaust	15,000	1/4	415	Direct		5	SD	450	415
#5	S.E.cor. Basement	Basement Supply	40,000	1-1/8	185	Poole	4.8:1	30	SD	900	840
#6	S.W. cor. Basement	Basement Supply	40,000	1-1/8	185	Poole	4.8:1	30	SD	900	840
#7	East half Basement	Basement Exhaust	40,000	1	333	Poole	8.8:1	15	SD	1200	1150
#8	West half Basement	Basement Exhaust	40,000	1	333	Poole	8.8:1	15	SD	1200	1150
#9	Basement N. Centre	Plunge and Gym Supply	40,000	1-1/4	416	Poole	8.86:1	20	SD	1200	1150
#10	Basement N. Centre	P.A.Supply & Mech. Rm.	80,000	1	587	Poole	4.8:1	7-1/2	SD	1200	1150
#11	Basement	Rm.from Plunge and Mech. Rm.	40,000	1	165	Chain		15	SD	720	
#12	Pent Hse.	Toilet Rm.S	65,000	1-3/8	215	Chain		25	SD	720	
#13	Pent Hse.	Toilet Rm.W	65,000	1-3/8	215	Chain		25	SD	720	

Units driven by Poole gears are to have Franke couplings.
Where boxes are called for as above, they are to be of cast iron extending ... fan and motor.

fans where required. Bishop-Babcock Ductstats are installed on the discharge of these fans to maintain a uniform discharge temperature and Bishop-Babcock rubber element thermostats are used to control the radiation on the first floor, the thermostatic control being confined to the first floor.

There are four toilets on each floor, two for men and two for women, the stools being J. L. Mott's West-Point suspendo, the lavatories J. L. Mott's Altoona pattern vitreous china and the urinals Beaver pottery and refrigerating porcelain interlocking type 24 in. in width. Sloane flushing valves are used on the stools and on the lavatories Bashlin white metal faucets with specially designed pop-up and 1¼ in. clean sweep trap. The urinal flush control is effected by means of J. L. Mott's foot operated floor valve.

Clock Service

A Stromberg secondary clock system is installed with Mercurial Pendulum Master Clock and relays at present installed for 400 clock capacity and provisions made for an ultimate of 2000 clocks. The secondary clock used has the impulse movement and especially designed flush mounting. Arrangement is made in each typical office for a possible clock connection. A nominal charge is made for clock service and is being installed as fast as required. The clock system is operated from a 24-v.

storage battery arranged for direct or motor generator charging. The master clock location is on the mezzanine floor in the center of the building. This was picked in order that building vibration would least affect accurate time keeping. The Still Alarm watchman system is installed. There are eight special bronze front boxes located on each floor of the main building and in appropriate locations in the laboratory and Power House.

In addition to the still alarm system which may also be used in case of fire, there are installed two Gamewell fire alarm boxes on each floor of the main building and one direct box in the office of the chief officer on the first floor. These are so arranged that anyone can turn in an alarm from any one of the boxes, except the main box in the chief officer's room. But an alarm so turned in calls out only the building fire department. If, upon reaching the scene of the fire, it is of sufficient magnitude to justify calling on the city, the the building fire

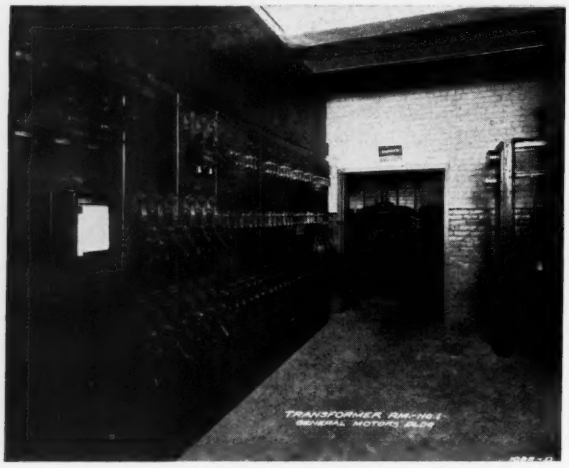


FIG. 12. ONE OF THE TRANSFORMER ROOMS

chief can, with a special key, turn in a city alarm from any one of these boxes. An illuminated Annunciator is located in the main corridor, east side, and arrangements have been made with the City Fire Department to enter by this door, whereupon they could find from the Annunciator the floor and wing of the building from which the alarm was sent.

Lighting and Power Distribution

Lighting and power distribution is carried at a voltage of 4600 to transformer rooms located in the basement of the main building and of the laboratory, the east half of the main building being connected to phase A, the west to phase B and the laboratory to phase C. In transformer room No. 1 are located three 150-kv.a. Maloney single-phase transformers to be used entirely for lighting. In transformer room No. 2, also located in the basement of the main building, are six 150 kv.a. Maloney single-phase transformers, three being used for lighting and three for power. An electrically interlocked tie line has been arranged between the two banks of lighting transformers so that one bank can be taken out of service for repairs during periods of light load, while the other bank is used to carry the entire building. The pump equipment in the sub-basement is controlled by a special power switchboard located in the sub-basement, which is fed from transformer room No. 2.

Transformer room No. 3 in the basement of the laboratory is equipped with two 200-kv.a. Westinghouse transformers used for light and six 150-kv.a. Pittsburgh transformers for power. The power served on this bank of transformers consists of 220-v., three-phase, in the Exposition Hall on the fourth floor of the laboratory, and motor generator sets in the Dynamometer room. The Exposition Hall, which is approximately 70 by 500 ft., has especially elaborate arrangements by which exhibitors may be furnished with 220-v., three-phase, or 110-v., single-phase current, or DC 110-220-v. current, as may be desired, and in addition to this they may be served with refrigerated brine, gas, cold water and waste connections by doing a small amount of exposed temporary piping.

Energy for building lighting is distributed to four panel boards on each floor, specially designed by the Mutual Electric & Machine Co. for metering the service to a maximum of about 30 per cent of the number of switches installed. In practice, it has been found that tenants take a sufficiently large number of rooms so that there has never been a shortage of meter arrangements. The Sangamo watt-hour meter was used in connection with these boards. Diamond-H flush switches were used for room control. A specially elaborate and convenient conduit system was installed for the lighting circuits in which home runs can be pulled from a number of different points in each wing. In addition to the conduit system for lighting, there is also installed a complete low tension conduit system from which buzzer and telephone service can be supplied each room.

Electric light fixtures are the Duplexalite D-231, of which two are installed in each typical office, measuring approximately 15 by 20 ft. with a 200-w. lamp. This arrangement gives approximately 7 ft. candles on the working plane when the lamps are new and the decorations fresh, with a reduction to about 5 ft. candles under worst conditions. The arrangement of lamps and selection of decorations gives unusually good distribution, with a utilization factor of about 40 per cent. The coefficient of reflection of the ceiling under these conditions being about 70 per cent and of the side walls slightly less. The special ornamental fixtures in the corridor and first floor shops and show-rooms were furnished by Caldwell, New York.

Lighting in the Auditorium is controlled by a Mutual Electric & Machine Co.'s mechanically operated pre-set three color switchboard, and there is also a moving picture booth equipped with two Power's motion picture projectors, each equipped with General Electric high power rotating arc and operated by a 75-amp., 60—120-v. type D-75-75 Hertner "transverter." Switching arrangements were also made so that the machines can be operated from the direct current.

Elevators

Elevator equipment in the building consists of 27 Otis Elevator Co.'s passenger elevators and four Otis freight elevators. The elevators serving the main building are 24 in number, arranged in four banks of six each. These elevators are designed for a speed of 650 ft. per min. and for a load of 3500 lb. Tests on them show the speed to be slightly in excess of this. The machine is known as size 18-33H and is rated at 55-hp. at

62 r.p.m. They are furnished with five-wire drive and micro-control. The micro motors are rated 6 hp. and operate from the 240-v. line, at 235 r.p.m. and are controlled by floor leveling cams adjusted to give a stop to within ¼-in. of correct floor level. The multivoltage current is supplied by two 300-kw. Otis motor generator sets located at the Power House. These are direct driven by 450-hp., 2300-v. induction motors. The elevator machines are controlled by Otis Controller style MV5-240-v. controllers. There are at present 12 of the 24 elevators installed in the main building and 6 additional ones on order. The control for these elevators is equipped with Elevator Supply Co.'s sequence contactors, which prevent the operators from starting the car on the hatchway gate. The gates are equipped with Norton door closers and Elevator Supply Co.'s electric interlocks. The elevators now in process of erection have the same arrangements as to control, except that the sequence contactors are mounted on a panel integral with the rest of the contactors and an additional individual cutout switch is also supplied.

Each elevator is equipped also with the Elevator Supply Co.'s mileage recorders and stop recorders, the latter being mounted on the elevator signal panels which were also supplied by the Elevator Supply Co. A Reliance automatic despatcher has been installed for the purpose of despatching cars during periods of regular operation. This despatcher is equipped with four independent adjustable timing wheels. The passenger elevators are all direct driven and the freight elevators two to one. The freight elevators are equipped with five-wire drive and micro control, the same as passenger elevators, and the hatchway openings are guarded by Quincy gates. All cars in operation at the present time are equipped with the Elevator Supply Co.'s intercommunicating telephone system.

Furnace Design for Effective Drying

SPECIAL ARRANGEMENTS OF GRATES AND ARCHES ARE ESSENTIAL FOR DRYING FUEL WITH HIGH MOISTURE CONTENT IN BOILER FURNACE. BY ZUCE KOGAN

ECONOMICAL utilization of moist fuel depends on the efficient combustion and on the amount of drying to which the fuel was subjected before its ignition. This latter which was usually done before the fuel entered the furnace is now accomplished within the furnace. The reason being that the necessary special apparatus is of such complicated design, great initial cost and so expensive to maintain that the practice of drying the fuel outside the furnace had to be abandoned. For this reason the modern furnace installation must be designed for effective drying as well as effective combustion. Moreover it is noteworthy that the drying is a more important problem than the combustion itself, as, should the former be inefficient, then not only would the fuel smolder slowly and give difficulty in maintaining the necessary steam pressure but the furnace would become absolutely worthless with very moist fuels.

These fuels can give no more heat than they contain minus that necessary for driving out its moisture. If the amount of heat left is used effectively, the fuel has some value; otherwise it is not worth the trouble of using it as fuel. Thus, supposing a fuel requires 50 per cent of its heat content for driving out its moisture, if we get rid of its water contents and the fuel burns with a bright flame and maintains the necessary steam pressure, and is also sufficiently cheap, then it becomes of real fuel value.

FURNACES INSTALLED UNDERGROUND

FURNACES for steam boilers using fuels of high moisture content are usually very large. The size may be from twice to five times the ordinary coal fed furnace. The reason for this is that the moist fuel is lower in specific gravity than ordinary coal fuel, the heat value per pound is less than good qualities of fuels, and the fuel requires much greater combustion space than the usual fuels. This is not all, as the process of drying necessary to be carried out within the furnace increases it greatly.

These very large furnaces, when installed in the boiler room, present three important disadvantages:

1. It takes a great amount of space in the boiler room and increases the initial cost of the boiler plant.

2. The heat from these large furnaces has greater chance to radiate through the brickwork into the boiler room atmosphere, causing a loss and an inconveniently high temperature for the people in the boiler room.

3. They are inconvenient to attend and make the feeding impractical and expensive.

All these disadvantages could, however, be reduced to a minimum by installing the furnace underground or beneath the boiler room floor. The floor space will be saved, as the boiler shell alone will be in the boiler room. The furnace brickwork will communicate with the earth and not with the air, therefore reducing to a great extent the loss of heat due to radiation; also the expense of refractory material will be reduced, yet it will facilitate the charging of fuel through the hoppers. There are many other advantages in the installation of moist fuel furnaces underground and most of them could be noted from the accompanying drawings showing the position of the underground passages for the easy accessibility for the cleaning and handling of grates during the working of the boilers; therefore the question of underground furnaces must be given consideration, especially with moist fuel where drying effect is obtained in the furnace.

EFFECT OF GRATES ON THE DRYING

GRATE arrangement influences very much the effectiveness of the drying of fuel before its combustion. The inclined grate becomes adaptable for the purpose of drying, as it permits taking advantage of the many features that are especially required for the drying process. Considering the grate proper, it was already pointed out in a previous contribution on "Grates" that the longer it is the longer the moist fuel will travel within the furnace on this grate, and the less it is inclined the slower the fuel slides on it and the longer it is in contact with the furnace heat, thus helping to produce a more effective drying.

To obtain the best possible drying, it would be necessary to arrange the grates at the least possible inclination and greatest possible length. This is quite important, but considering the matter from a practical point of view it may be said that this arrangement would have many disadvantages. Considering the length of grate,

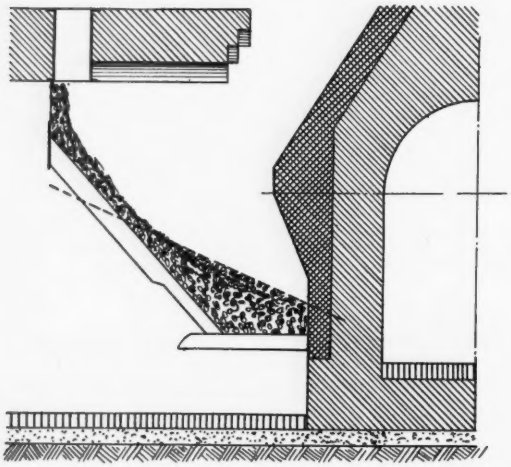


FIG. 1. THIS TYPE OF GRATE GIVES AN UNEVEN THICKNESS OF BED WITH MOIST FUELS

we know that the grate must be in some relation to the boiler rating and that its width must be in some proportion to its length. Second, increasing the grate length would increase excessively the radiation of heat to the underground passage. Considering the inclination, it may be said that its function is not for drying alone, as it must also be arranged in a manner to facilitate the fuel's sliding along the grate. This sliding, which is absolutely dependent on the inclination of the grate, is increased as the inclination is increased. This latter being just the reverse of the requirements for efficient drying, the inclination of the grates therefore becomes limited.

Grates of Double Inclination

In order to meet the necessary requirements and to overcome the disadvantages, the grates may be arranged as shown in Fig. 2 instead of as in Fig. 1. In the former, the small grate, B, which is usually designed in a horizontal position, is now changed to a slightly inclined position, while grate C is installed with a greater angle of inclination as compared with Fig. 1. The reason for inclining the small grate is especially for making the whole grate arrangement somewhat longer so as to give the green fuel a longer travel within the furnace for a more effective drying.

It may, however, be interesting to mention that the inclination of the small grate has another important advantage which is worthy of consideration. By comparing the fuel beds in Figs. 1 and 2, we can easily see that in the latter the fuel bed is more nearly parallel to the refracting arch than in the former, therefore, it may be said that increasing the inclination of grate B, makes the fuel-level more nearly parallel to the refracting arch and improves the ignition-reflective effects of the arch. On the other hand, such a grate arrangement is easy and cheap to install, as this can be done by simply lowering the end of the grate that is to be fixed to the brickwork. Increasing somewhat the fuel travel permits us to give more inclination to the large grate C and cause easier sliding of the fuel.

Brickwork Instead of Grates

Double inclined grates are no doubt an improvement for use with moist fuel, but the effect is insignificant due to the fact that the increase in grate length is extremely small.

Considering further the question of grate length, we find that the object is to increase the travel of fuel within the furnace. Perhaps, however, some arrangement other than grates would adapt itself better for this purpose, because in reality the grate is not in this case the right apparatus to be used, as grates are designed more especially for combustion than for the drying of fuel.

Practically it is quite incorrect to apply grates for drying and this use should be avoided whenever possible or whenever a heavy duty of drying is required. To avoid this, an extension of brickwork, AB, Fig. 3, along

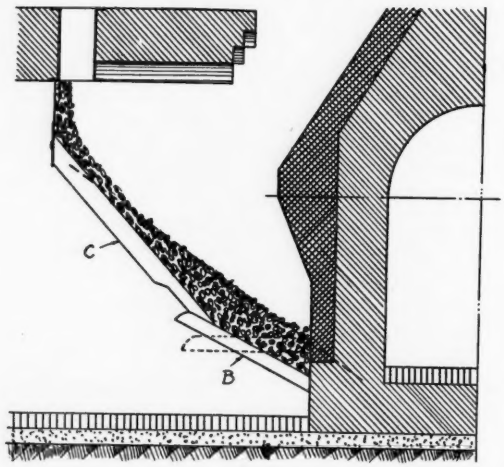


FIG. 2. WITH THE SMALL BOTTOM GRATE INCLINED A MORE EVEN FUEL BED THICKNESS IS SECURED

the grate may be used for accomplishing this result. This additional brickwork prevents interference of the drying process with the work of the grates. It also reduces the loss of heat due to radiation through the metallic grate to the underground passage communicating with the atmosphere or the boiler room, as there is refractory brickwork instead of metallic grates. Moreover, the brickwork, being a poor conductor, does not lose the heat that has been reflected or refracted to the moist fuel lying on it, but on the contrary retains this heat and gives the moist fuel more chance to absorb it and to be more effectively dried.

Arch Arrangement for Effective Drying

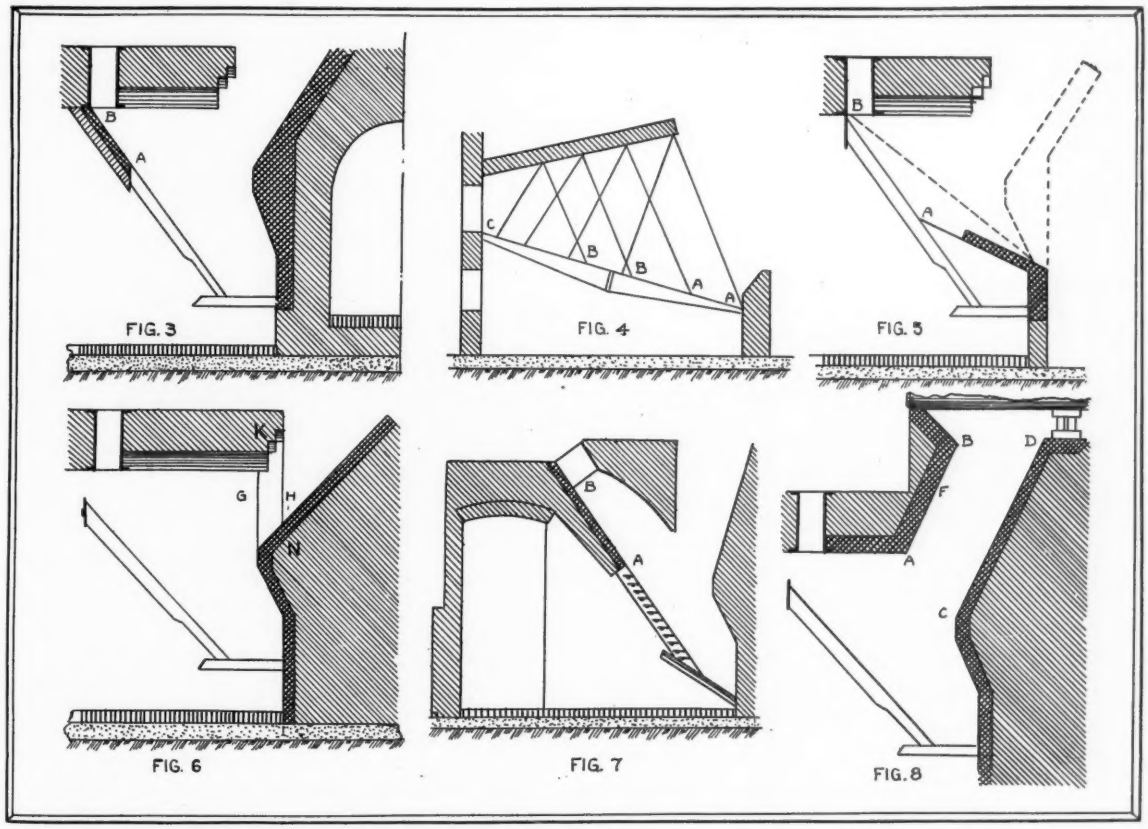
Using arches for the drying of fuel simply assures that the green fuel is subjected to a sufficiently intense heat for quick and effective drying. This is generally considered necessary because the green fuel entering the firebox must be dried by its own heat content and the temperature is not uniform through the whole furnace space, being hottest near the combustion zone. The grate being very long, the green fuel is considerable distance

from the combustion zone and therefore is not sufficiently dry before it descends to the combustion zone for ignition.

More intense heat is required at the upper part of the grate which calls for the use of special arches that will reflect or refract the heat from the combustion zones to the upper part of the furnace where the moist fuel enters.

Use of arches is an old practice but merely for combustion and not for drying. We have experimented with arches placed at the front end and also at the rear end of the furnace without regard to their special features. The arches placed at the front end were always designed the grate, as the fuel being more moist will smolder at the front end. Now the heat radiated from the arch is insufficient while the fuel lying under it tends to abstract the heat from the arch above which results in an ineffective drying with the front arch.

Considering, however, the other illustrations where the arch is at the rear end, the heat near the bridgewall which is the most intense of the furnace is radiated onto the moist fuel causing therefore the efficient drying. Moreover, the cooling of the arch from the moist fuel, as with Fig. 4, is impossible, as the arch is over the most intense heat of the furnace and cannot be cooled. For this reason it is important to consider the position of



ARCHES FOR DRYING FUELS WITH HIGH MOISTURE CONTENT, IN THE FURNACE

Fig. 3. Inclined firebrick hearth aids in drying. Fig. 4. Reflected rays from hottest zone of fuel bed do not reach front of grate with this arch arrangement. Fig. 5. Comparative area covered by reflected and refracted heat rays. Fig. 6. Overlapping arches prevent radiant heat reaching boiler shell. Fig. 7. This type of furnace has a special drying chamber. Fig. 8. Parallel walls insure complete combustion of gases.

not only for the ignition of fuel, but for the drying, too, and its drying effect on the moist fuels was ignored. The reason is that the arches at the front end are quite effective with fuel of low moisture content, but not with fuels containing a high percentage of moisture.

Position of Arches

In order to consider the installation of arches at either end of the furnace, let us consider the quantity and intensity of heat radiated from each of them. Considering Fig. 4 with an inclined arch at the front end of the furnace, we can readily see that the hottest rays, A, A, hardly reach the green fuel, C, at the front of the furnace, while the rays B, B, are much cooler due to less active combustion nearer to the front end of the arches when designing steam generators for moist fuels.

Lower Drying Chamber

Other than the position of the arches, the choice of the type of arch is of great importance in furnace design. Before deciding on it, we need to take into consideration that the heat must be projected to the top of the grate, where the fuel enters the furnace. To do this with an arch of reflecting type we will always find great difficulties while it is most easily done with an arch of the refracting type. It may be noted from Fig. 5 that the projection of heat with these types is not the same. The reflected rays cannot be projected farther than at A while the refracted rays can even reach point B.

On the other hand as mentioned in my contribution "Brickwork" (Nov. 15 issue), the refracting type of arch is more effective due to the bending of flame proper instead of simply reflecting the heat. For this reason, it may be concluded that as far as the drying of moist fuel is concerned the refracting arch is preferable. There is another important advantage of the refracting type of arch. As may be noted from Fig. 5, the reflecting type of arch always acts as a baffle plate between the flame of combustion and the boiler shell. This is very impractical because it does not permit the radiated heat to reach the boiler shell and thus reduces to a great extent the efficiency of the furnace. Not only does the heating efficiency become reduced with such a type of arch, but even with the refracted type when this principle is not observed. It has been ascertained that the boiler efficiency will decrease as the brickwork K will overlap N, Fig. 6. The reason may be said to be due to the fact that the furnace is very large and only the end of the flame can reach the shell. If this is obviated by using the reflecting type of arch or by overlapping brickwork, GH, the heating value is reduced.

Upper Drying Chamber

Considering again the arches for refracting, we have pointed out that one of the principal uses is to project the heat far enough toward the upper end of the grate where the moist fuel enters. This is quite effective for helping to dry the fuel on the grate itself, but should we employ the brickwork extension, the refracted flame also becomes insufficient. For this reason, to heat well the moist fuel on top of the brickwork, a special arrangement of arches is preferable. An effective arch for this purpose is illustrated in Fig. 7, in which case the arch is arranged in such a manner as to catch the heat rays from the lower part of the grate and reflect them to the whole length of the brickwork where the moist fuel is traveling.

Being assured that the fuel on the brickwork is drying, it is then permissible to increase its length so that the travel of fuel while drying may be increased to dry the fuel more thoroughly. Referring again to Fig. 7, this arrangement appears as two distinct chambers; one is the upper brickwork with a circular reflecting arch for the drying, the other with the grate and refracting arch for a combination of drying and combustion purposes. The upper chamber being absolutely independent of the lower, permits arranging this at will. It is not limited by the grate brickwork as would be the case if only one chamber were used. Secondly, both chambers arranged in this manner make what we may call a real drying and combustion furnace that dries its fuel automatically.

Preventing Gases from Escaping Unburnt

Another important question to be taken into account is the prevention of unburned gases escaping to the stack. To do this, it is possible to fill the gas passage at the bridgewall with firebricks arranged in a manner to make a large number of small passages, in which case the gases passing these narrow passages come in contact with the white hot brickwork and ignite. Another effective method is to pass the gases between parallel brickworks which are well heated, in which case the gases are affected by these radiated heat rays and are ignited.

Both designs could be installed in a manner to give good results, but the former is complicated especially with the moist fuel furnace, which limits its use. In order to construct the latter, the brickwork may be overlapped; but as just mentioned, this method of overlapping is very uneconomical due to interference with radiating heat to the boiler. In this case, the brickwork AB is inclined so as to be parallel to the brickwork CD of the arch. This does not affect the furnace arrangement much, due to the fact that the inclination CD is small (permitting easy cleaning of clinker), therefore to make AB parallel it needs also but a small inclination. As mentioned in the article on "Brickwork," the part AF could be arranged to accomplish this purpose, but it is always best to use a greater portion of the length AB to insure complete combustion of the gases. This installation does not require any difficult alteration, nor any more expensive boiler installation, while it is always an important question with fuel efficiency.

Failure of Welded Head in Air Receiver

By R. L. Hemingway

Having served its useful life as a boiler, an old boiler shell was converted into an oil tank by removing that portion of the head which had formerly been occupied by the tubes and replaced by a flat piece welded in by the acetylene process.

Some time later, a contractor had need of an air receiver, and his choice fell on this old boiler which he was advised was safe to carry 40 lb. There is no available information to show whether it was a certified inspector who gave this advice, or some smooth selling talk on the part of the owner. In any event, the contractor thought that it might be used for 80 lb. pressure, which pressure proved too much for the weld and as a consequence the piece blew out, injuring a laborer, who subsequently suffered from a complete loss of memory.

As the boiler shell in question is said to have been 30 in. in diameter and to have a ⅜-in. head, this failure would seem once more to demonstrate how completely the lay mind fails to grasp the meaning of the phrase "pounds per square inch." A 30-in. head has an area of somewhat over 706 sq. in. If, now, 80 lb. pressure is applied to each square inch, we have a total pressure of 56,480 lb. tending to push the head outwards. This would require at least seven stays having an area of one square inch to support the head safely.

There is a great deal of trading in old vessels of this kind and one may be practically sure that by the time they have reached the stage of being used for an oil tank their days as pressure vessels are over.

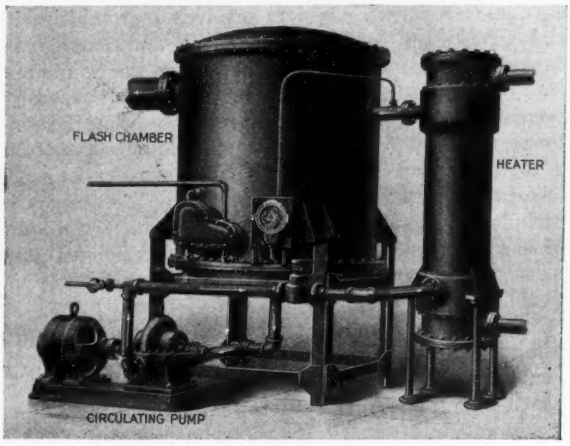
It is hoped that this short narrative may serve as an object lesson to those who may contemplate in the future the purchase of secondhand shells for pressure purposes. All such pressure vessels should only be purchased after the fullest possible investigation and then should only be operated at a pressure which has been fixed by a qualified and duly certified boiler inspector.—California Safety News.

About the only knock we care to hear is opportunity's.

Savings Effected by Evaporator

LOW PRESSURE EVAPORATOR FOR MAKE-UP WATER INTRODUCES A SAVING IN PLANT OPERATION. BY JOHN FORBES*

SOME OF the advantages of using pure water for boiler feed are that pure water contains no scale forming impurities, and for this reason scale deposits in the boiler are eliminated and a high boiler efficiency is obtained. Boiler blow-downs are practically unnecessary, hence the heat that is ordinarily lost in blowing down is saved. Boiler repairs such as tube renewals and minor replacements are minimized, and boiler cleaning in order to remove sludge, suspended matter, and other impurities in the water is dispensed with. High overloads can be carried without foaming or priming.



LOW PRESSURE EVAPORATOR SYSTEM

The investment in boiler capacity is a minimum. The highest capacity that a boiler can develop is determined primarily by its ability to generate steam without priming. Impure water, because of the mud, sludge and other solid matter held in suspension, ordinarily foams and primes at slight overloads, whereas pure boiler water permits boiler overloads up to 400 per cent rating to be developed without priming. This means that to carry a given load when pure feed water is being used, the rated boiler capacity required is less than for impure water. Consequently there is a material saving in boiler plant overhead and investment costs.

Evaporating systems for producing pure boiler feed water consist essentially of a boiler or evaporator and a distiller or vapor condenser. Raw water or brine is boiled in the evaporator and the vapor formed is condensed in the distiller. This condensed vapor or distillate is for all practical purposes chemically pure water.

In the system shown in the accompanying illustration, raw water is heated in the tubular heater to a temperature that is below the boiling point at atmospheric pressure and also below the temperature at which the impurities are deposited as scale. This temperature is also higher than that corresponding to the vacuum maintained in the evaporator. The circulating pump maintains a pressure on the water in the heater and as this water enters the evaporator it flashes into vapor on account of the vacuum existing in that compartment.

*Engineer, Schutte & Koerting Co.

Although many of these advantages are well known, the money saving that they represent in the yearly operation of the plant is not as universally recognized. To make this matter clear, an example covering conditions in a typical small steam power plant is given, and it is shown that the savings effected in one year's operation with pure boiler feed is more than 50 per cent of the initial cost of the evaporating system.

Economical Aspects of Pure Feed Water

ASSUME THAT we have 2000 hp. of boilers (manufacturer's rating) operating at 150 per cent rating, 10 hr. a day, 307 days a yr., or 3070 operating hr. per yr., and that the evaporation is 8 lb. of water per hr. (from and at 212 deg. F.) per lb. of coal.

Boiler feed make-up: 5 per cent of the total evaporation.

Boiler blow-down, when an evaporator is not used: 2.5 per cent of the total evaporation.

Boiler pressure: 200 lb. per sq. in. abs.

Cost of coal: $5.00 per T., in the fire box.

Cost of purchased water: $1 per 1000 cu. ft.

Percentage of the fuel that is wasted due to the presence of scale in boilers is shown in the accompanying table. If in our problem the boiler scale averages 1/16 in., then the elimination of this scale by the use of pure distilled water will result in a yearly saving of

TABLE I. WASTE OF FUEL DUE TO BOILER SCALE

Scale Thickness, Inches	Percentage Fuel Wasted	Scale Thickness, Inches	Percentage Fuel Wasted
1/64	2	¼	38
1/32	4	⅜	48
1/16	8	½	60
⅛	18	⅝	74
3/16	27	¾	90

$$1.5 \times 34.5 \times 0.08 \times 3070 \times 5.00 \div 8 = \$7940.$$

Factor of evaporation is $f = (1198.1 - 28.08) \div 970.4 = 1.2057$, in which 1198.1 is the total heat of steam at 200 lb. abs., and 28.08 is the heat of the feed water. The quantity of hot water lost per hour in the boiler blow-down is assumed to be 2.5 per cent of the total boiler evaporation, or

$$2{,}000 \times 1.5 \times 34.5 \times 0.025 \div 1.2057 \text{ lb. per hr.}$$

Each pound of water in the blow-down wastes a quantity of heat equal to the difference in the heat of liquid of the boiler water and of the feed water, or $354.9 - 28.08 = 326.82$ B.t.u. Since the equivalent evaporation from and at 212 deg. F. is 8 lb. of water per hour per pound of coal, the actual evaporation is $8 \div 1.2057$. Hence the heat absorbed per lb. of coal burned is

$$8 \div 1.2057 \times (1198.1 - 28.08).$$

Finally, the saving per year due to the elimination of the boiler blow-down is

$$2000 \times 1.5 \times 34.5 \times 0.025 \times (354.9 - 28.08) \times 3070 \times 5.00 \div [8 \times (1198.1 - 28.08) \times 2000] = \$695.$$

Make-up water was assumed to be 5 per cent, and was purchased at a cost of $1 per 1000 cu. ft. When an evaporator system is used, any available supply of

raw or brackish water can be used to supply the distilled make-up, hence the saving involved is

$$2000 \times 1.5 \times 34.5 \times 0.05 \times 3070 \times 1.00 \div 1.2057 \times 62.5 \times 1000 = \$210.$$

Savings on boiler repairs will account for say $900 a year for a 2000 boiler horsepower steam power plant. Tube renewals and other replacements on the boilers, economizer and piping due to the corrosive action of impure feed water will amount approximately to $200.

Fixed and Operating Charges of Evaporator System

Yearly expenses that must be charged against the evaporating system include the annual fixed charges, the cost of the heat lost in evaporator blow-downs, radiation losses, charges for labor and upkeep, and the cost of power consumed by the auxiliaries, including the feed, circulating, discharge and vacuum pumps.

For supplying the boiler feed make-up under the given conditions of the problem, the cost of an evaporator is about $13,000 which includes the cost of the piping, etc. The annual fixed charges, ordinarily taken as 10 per cent of the initial cost, will amount to 10 per cent of $13,000, or $1300.

Blow-down from the evaporator is about 4 or 5 per cent of the total evaporator feed. If the evaporator is of the low pressure type, the water is vaporized at comparatively low pressures and temperatures, and consequently the heat lost in the blowoff is relatively small.

If the temperature of the evaporator blowoff is taken as 134 deg. F., and the temperature of the raw water feed as 60 deg. F., then the heat lost in blowing-off 1 lb. of liquid is 101.88 — 28.08 = 73.8 B.t.u. Thus the cost of the coal that is lost in 1 yr. in the blowoff is:

$$1.5 \times 34.5 \times 0.05 \times 0.05\ (101.88 - 28.08)\ 3070 \times 5.00 \div (8 \times 1170.02) = \text{about } \$15.$$

If the radiation surface is taken as 800 sq. ft. and the loss per hr. per sq. ft. as 50 B.t.u., then the cost of the coal lost per year through radiation is

$$800 \times 50 \times 3070 \times 5.00 \times 1.2057 \div (8 \times 1170.02 \times 2000) = \$50.$$

If the evaporator is provided with both an automatic feed and an automatic blowoff, one man at $1500 a yr. can operate the apparatus satisfactorily by giving it one-third of his time. Thus the labor charge is about $500 a yr., which, plus a miscellaneous upkeep charge of another $500, makes a total charge of $1000.

Power requirements for the necessary pumps will amount to about $800 per yr.

Thus the savings effected by the evaporator installation are as given in Table II.

TABLE II. SAVINGS EFFECTED BY EVAPORATOR INSTALLATION

Due to no scale formation in tubes	$7940
Due to no boiler blow-down	695
Due to no cost for make-up water	210
Due to no boiler repairs (take-down and maintenance)	900
Due to no corrosion in boilers, pipe lines, economizers, etc.	200
Total savings per year, in plant operation	$9945
Charges that must be debited against the evaporator system are:	
Annual fixed charges, 10 per cent of first cost	$1300
Evaporator blow-down, 5 per cent of total evaporator feed	15
Radiation losses	50
Labor charges	1000
Power for auxiliaries	800
Total charges per year against evaporator system	$3165
Total savings per year in plant operation	9945
Total charge per year against evaporator system	3165
Net yearly balance	$6780

Ordinarily evaporators for supplying pure boiler feed make-up water cannot be economically run in non-condensing plants or in plants operating jet condensers where it is necessary to produce approximately 90 per cent of the total boiler feed. Under these conditions an adequate evaporating system involves a prohibitive initial investment. Quite frequently additional boiler capacity is also required for handling the evaporator.

Surface condensing plants can utilize an evaporating system most economically and profitably when the water losses, or boiler feed make-up, is a minimum, say between 3 to 5 per cent of the total boiler evaporation. The losses that must be compensated for by the evaporation include boiler safety valve blowoff, steam consumption of soot blowers, turbine gland leakage, exhaust steam losses, condenser leakage, and condenser air pump suction loss.

These losses should be examined closely and kept at a minimum at all times. For the ordinary plant under usual conditions, the make-up should not exceed 5 per cent of the total boiler evaporation.

Operating tests of a carrier current telephone system of communication were held recently in Baltimore by the Pennsylvania Water and Power Co., which has installed the system on its 40-mi., 70,000-v. transmission line between the Holtwood (Pa.) hydroelectric generating station and a sub-station in Baltimore. Communication under varying conditions was effected in both directions. The Pennsylvania Water and Power Co. is among the first three companies to adopt carrier current for regular commercial operations. The system was installed first by the Utica Gas and Electric Co., Utica, N. Y., and it has also been in operation recently by the Hartford Electric Light Co. The tests at Baltimore were made under the direction of F. A. Allner, engineer of the operating company in conjunction with engineers of the General Electric Co., who installed the system. Mr. Allner is chairman of the Radio Committee of N. E. L. A.

Direct current at 1000 v. was generated by a motor generator set fed from a 220-v. storage battery. This is then passed through a 50-w. pliotron oscillating tube which gives about 5000 v. a.c. at 15,000 cycles. This current is then transferred to the transmission line through a capacitive coupler. A second 50-w. tube used as a modulator is then employed to superimpose the voice frequency on the higher frequency current and the voice frequency is thus carried along with the carrier current. Reception is effected by apparatus similar to that used in ordinary radio employing one detector tube and two-stage audio frequency amplification. It is possible also to ring a signal bell before beginning conversation.

Pointers on the Inspection of Steam Turbines---I

MAKE IT A PRACTICE TO MAKE A THOROUGH INSPECTION AT LEAST EVERY SIX MONTHS. BY JOHN T. WILLISON

STEAM TURBINES like any other class of mechanical equipment require inspection at regular intervals in order that slight troubles may be remedied before they become serious, and to be able to keep on hand such parts and supplies as may be required to deal with renewals or breakdowns. The frequency of such inspection (apart from those made in daily operation) will depend largely upon the conditions surrounding each machine and to a great extent upon the opportunities for shutting down.

Inspection of parts easily accessible without dismantling, should be made at intervals of not more than 2 mo., while a thorough overall inspection should be made at least every 6 mo. A systematic routine should be followed and all conditions recorded for comparison

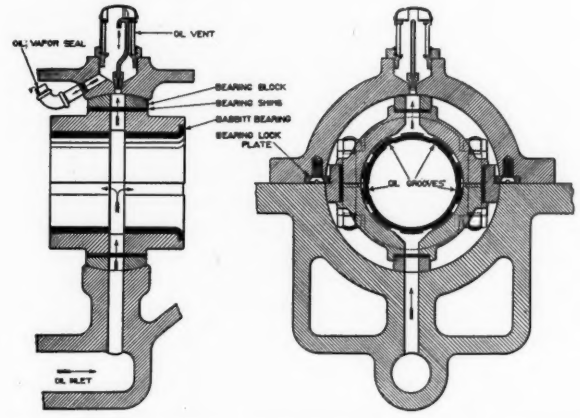


FIG. 1. TYPICAL EXAMPLE OF A STEAM TURBINE BEARING

with previous reports, and for future reference. There are several types of turbines, made by different manufacturers and a description of the method of inspecting any one make of machine may not be of much service to the engineer in charge of a machine of another make; however, if the engineer has a knowledge of the principles of turbines, and their action, a general description of turbine inspection can apply to all turbines.

It is wise to acquire a correct knowledge of the peculiarities and the sounds of a machine when running. Any change in the nature of the sound will then attract the attention of the engineer. A good plan is to listen to the sounds inside the casing by gripping a pencil or piece of steel between the teeth and stopping up the ears with the fingers and then placing the point on the turbine casing when a highly magnified sound will be heard.

OILING SYSTEM

PROPER LUBRICATION is a very important factor in successful turbine operation. It is a good plan to make provision in the return oil lines of a flood oiling system (a pipe tee will do) for a thermometer which can be immersed in the stream of oil flowing back to the pump and the temperature regularly noted as a rising temperature is generally an indication of coming trouble. A slightly lower temperature will be recorded at that point than exists in the bearing but this can be allowed for. The tee should be placed close to the bearing.

Low reading pressure gage should be installed in the supply lines leading to bearings and governor relay valves. The pressure, when all is known to be in good

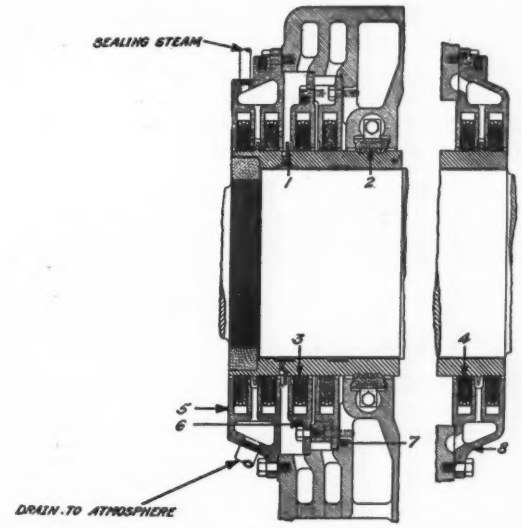


FIG. 2. DETAILS OF CARBON PACKING. (1) DEFLECTOR RING. (2) PACKING RING FOR TURBINE HEAD. (3) CARBON PACKING (HIGH PRESSURE). (4) CARBON PACKING, LOW PRESSURE. (5, 6, 7, AND 8) CARBON PACKING CASES

condition, should be noted, then any change can be noticed. An increasing pressure generally denotes clogging of the strainer while a decreasing one may indicate the pump going wrong or a break in the filter cloth in the strainer basket. The contents of a strainer basket should be minutely examined as this often reveals troubles such as cutting of the thrust and main bearings or gears not otherwise noticeable. The basket should be cleaned by blowing steam or air through the filter gauze and closely examined for breaks especially where the filter cloth is secured to the basket. Empty the oil tank, clean out the sludge or other sediment deposited, and wipe out clean, using a wiping cloth free from lint, instead of cotton waste. Blow air or steam through the pipe lines whenever possible. This will clean out sludge, gumming oil, etc.

All pressure regulating valves should be taken apart, cleaned and reset by means of a reliable pressure gage using any available means of getting a pressure for testing purposes. Take the auxiliary oil pump apart, clean out the casing and impeller; if turbine driven closely examine the rotor buckets, shaft and packing. The main pump, whether it be a separate unit or gear wheel type driven from the turbine, should have special attention. If of the gear wheel type the side clearance between wheels and casing is important, there should not be more than 0.002 in. between wheel sides and casing as this is where most of the slip is to be found.

Sight holes in the return lines at every bearing are very necessary for the inspection of the flow of oil through the bearings. Prior to making a bi-annual inspection the pipe lines, joints of gear casings and bearing caps should be looked at and all leaks noted and corrected when again assembling.

In water-cooled oil systems where the oil and water are contained in adjacent chambers of a cast iron tank divided by a partition which is part of the casting, it is worth while to examine and test for leakage due to cracked or porous metal, thereby allowing the water to mix with the oil. The water chamber and the cooling tubes should be cleaned of sludge and slime. The inside of the oil cooling tubes should be cleaned of dirt and gumming deposit. A wire with a piece of cloth attached to the end can be used for cleaning the inside of the oil tubes. Strainers on the water lines should be opened out and the strainer basket cleaned of mud, sand, or

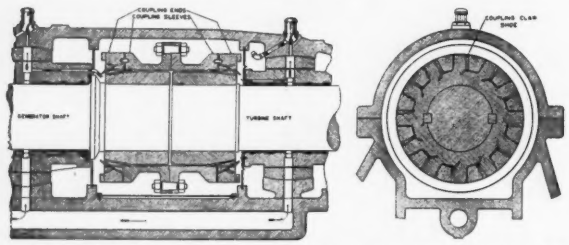


FIG. 3. DETAILS OF FLEXIBLE COUPLING FOR STEAM TURBINE

other obstructions. The oil cooling tubes should be tested for leakage due to cracks in the pipes and where they are connected to the heads.

Bearings

Turbine bearings which are mostly of a totally enclosed type are not easily accessible for inspection. When making a bi-annual thorough inspection, therefore, the bearings should receive close attention. In small turbines the bearings may be of the plain sleeve, ring oiling type. These can be checked for wear by using inside and outside micrometers to measure the shaft and bore respectively. The bore and oil grooves should be scraped clean of all gummy deposits; any wear endwise can also be noted.

For larger turbines, self alining, white metal lined split type bearings with spherical seats are mostly used. With the shaft removed, the bearing lining is scraped on all rough and high spots and cleaned of the gummy deposit which will form even with the best oil and oiling system, the oil holes and grooves are cleaned and all sharp edges scraped off the grooves. The bottom half of the bearing does not need oil grooves but should be scraped clear of the shaft for about 30 deg. on each side of the joint.

To measure the clearance between shaft and bearing the old time method of "leading" can be used. Pieces of lead wire are laid on the shaft at the two ends and the center, the top half is then bolted down hard, the thickness of the flattened wire can then be measured with a micrometer. This should give the clearance between the shaft and top half of bearing. An allowance of 0.002 in. per in. of shaft diameter is enough for good running.

It is not advisable to "let" bearings together by planing the joints for this would spoil the fit of the bearing shell and its seat and would necessitate using shims between the shell and the seat, not a desirable job at any time. When the wear becomes excessive there will probably be vibration which is not good for high speed machinery. The best remedy for this is re-lining of the bearings. In the spherical, self-alining bearing, it is also essential that a good fit be maintained between the bearing shell and its housing, not too tight to allow movement to suit the changes in alinement due to expansion and not loose enough to chatter when running.

Thrust bearings vary with different manufacturers in the method of adjustment. It is well to examine the faces of the thrust collars on the shaft and bearings and if scored the faces should be trued up smooth. If threaded collars or split bearings moved by screws in tension and compression, it is only necessary to locate the shaft in its proper position and lock the collars or half bearings in position, allowing a few thousandths of an inch clearance to take care of the expansion of the shaft when running.

Packing

Badly fitted packings on turbine shafts are the cause of loss through steam leakage in a high pressure unit and loss of vacuum in low pressure condensing units, also heating, cutting of shafts and vibration. The most familiar type of shaft packing is made of carbon rings in three or four segments held in circular shape by spiral tension springs. The rings should be a good fit in their grooves and be free to change their positions due to expansion and construction of the turbine casing. Too loose a fit allows rust and sediment to form between the ring and the sides of the grooves. The bore of the rings should not exceed the diameter of the shaft by more than 0.002 in. to 0.003 in. per in. of shaft diameter. The joints between the segments should have a good bearing over their whole surface. The springs should be examined to see if there is sufficient tension to keep the ring firmly together. The stops to prevent the rings from turning with the shaft should be in good condition.

To test out the side clearance a set of feelers can be used, while the bore can be checked with a micrometer if the segments are assembled on a flat surface and held together with their springs. It is a good idea to have a short piece of pipe or shaft turned to the size of the turbine shaft to use in fitting together carbon packing rings. Old rings too large for the shaft and if not broken can be refitted for much less than the cost of new ones, by filing off the ends and so reducing the diameter of the bore. If the rings are worn too much to make a good fit in this way more can be taken from the ends and the rings rebored, always bearing in mind the necessity of facing up the ends true.

Drains in the packing cases should always be well cleaned out whenever possible as the condensation from leakage when the turbine is not in service may cause corrosion of the shaft under the rings and this roughened surface would wear the rings very quickly. Metallic packing rings are often used, usually made with saw teeth, sometimes called labyrinth rings, and in some cases the ordinary type of gland and stuffing box is used with braided metallic packing. This packing, if it has become hard, should be replaced. In fitting new packing, which is generally molded to shape, it is best to open this out in a spiral form to spring it over the shaft to prevent as much as possible the distortion at the mid-

dle of the packing, or it could be cut in two segments and the joints of the successive rings staggered. There are several designs of packings and supporting springs each with its own peculiarities which the engineer must handle as the circumstances require.

Alinement

Many of the difficulties that arise in turbine operation such as hot or worn bearings, leaky packing, vibration, broken shafts caused through crystallization especially in high speed machines could, if traced to their source, be rightly attributed to bad alinement of shafts.

Machines, whether mounted on one or more bedplates when on the manufacturer's testing floor, may be perfectly alined, but any bedplate of a reasonable section can be sprung while handled in transit or in course of erection, or be pulled out of shape by the anchor bolts, etc. Units may be lined up perfectly when erected but may develop misalinement due to faulty foundations, inadequate dowelling, heavy piping without proper provision for expansion or proper supports to relieve the turbine from strain. With these facts in mind, the engineer in charge will not misspend his time checking up the alinement whenever convenient.

Some manufacturers have small pads accurately planed and scraped when on the testing floor which are meant to be used in levelling and setting their machines. A good level from 8 to 12 in. long with a good straightedge can be used to level the machine in all directions. In using a level it must be turned end for end and the bubble measured from each end or from a center line scribed on the top of the level to ensure accuracy.

A fine steel wire (piano wire is generally used) stretched tight is sometimes used by stringing over the pads and measurements recorded by the maker when erecting in the shop checked. Owing to the sagging of the wire, this method has disadvantages. A machine already installed may be checked for alinement by stretching a fine steel wire through the bearings. This must be rigidly supported at both ends, then accurately centered at the two ends as a preliminary to checking the other bearings. With an inside micrometer the distances from the wire at four points of the bore and at both ends are measured and recorded. If these dimensions show the bearings to be out of line, it is necessary to move the bearings by whatever means is best for the existing conditions, maybe by moving the bearing pedestal and re-dowelling or by rebabbiting the bearings to suit the line. If a micrometer is not available a pin gage made of wood about ¼ in. square with two ordinary pins driven in is as good or in the writer's opinion better as a more delicate touch can be felt. It is obvious that this method can be used only when a machine is dismantled.

Where the driving and driven units are connected direct, this method is applicable but is more necessary in machines driven through reduction gear, so as to get the pinion and gear shafts perfectly parallel.

Another method commonly used as being more convenient is that of checking the alinement by the distance between coupling faces and by their diameters. This requires little or no dismantling, the necessary tools being a 6-in. steel straightedge, and a set of feelers or a steel wedge. A steel wedge made in the following way amply repays one for the time spent in making it.

Accurately face up a piece of steel ½ in. wide by 10 in. long to a thickness at one end of 0.1 in. and to 0.3 in. at the other. Divide the 10 in. into 10 equal parts and sub-divide these tenths again into tenths, the divisions 0.1 in. apart will measure 0.02 in. in thickness while the sub-divisions will register on each line 0.002 in. As the sub-divisions are 0.1 in. apart, no difficulty will be experienced in measuring to a one thousandth of an inch.

To check up the alinement proceed as follows: If the coupling is of the pin driven type, insert one of the pins into the two couplings and leave it there. Spread the faces apart until the shafts come up solid against their respective collars, then insert the wedge or feelers between the faces at top, bottom, near and far sides. Record the measurements obtained and turn the shafts through half a revolution, then repeat the measuring. Should all the measurements be the same, the shafts are in line. If the measurements are not all the same, the shaft may be out of line or the faces may not be true. A condition like the following may exist. In the first position, the top width may be 0.250 in. and the bottom 0.253 in., then when a half revolution is made the top reads 0.253 in. and the bottom reads 0.250 in. This would indicate the shafts in line and one or both faces not square with the center line. A little thought will suggest which way the shafts are out of alinement if the widths between faces are not equal, making allowance for discrepancies due to faces being out of square. A

FORM USED IN MAKING TURBINE INSPECTION

Empire Steel Corporation

Turbine Inspection

Turbine No. C-5 Date 6-21-22 Last Inspection 1-20-'22

Kind of Inspection Overhaul

Oiling System

Pressure to Bearings 3# To Pilot Valve 35# Temp. of Oil Leaving Bearings 156° F Temp. of Cooling Water 70° F

Condition of Oil dirty When Replaced Last April 20, 1922

Strainer dirty — gauze broken

Cooling Tubes — Water Side Covered with slime

" " Oil Side

Cooling Tank Considerable sediment and slime

Bearings	Condition	Clearance
Rotor Shaft	Good	.004"
Pinion "	Scored and rough	.008"
Gear "	Good	.012"
Shaft Packings	Worn slightly	

Oil Pump Driving end of shaft and bearing worn, 0.003" side clearance

Alignment

Space Between Coupling Faces Top 0.123" Bottom 0.120" R.H. Side 0.122" L.H. Side 0.122"

Foundation Level Crosswise Ok Lengthwise Ok

Governors	Drive Wheels	Shafts	Fulcrums
	Teeth badly worn	scored	chipped and reamed

Running Speed Under Load 3600 r.p.m.

Overspeed Knock Off 3785 r.p.m.

Vacuum Breaker Opens sluggishly — needs cleaning

Steam Regulating Valve Seat & valve leaky

Condenser

Tubes — Water Side — Steam Side

Condensate Pumps Under Load 900 r.p.m.

Glands and Packing packing needs renewing

Vacuum When Running Under Load 28"

Temp. of Cooling Water 70° F Temp. of Condensate 78° F

Steam Pressure at Regulating Valve 9# Gauge

Air Pump Pump rod loose and worn

Blading A slight groove and a few bent blades in 1st stage nozzle ring

Foundation A slight crack at governor end

Steam Pipes Bolts used securing exp. end supports pulled up

Remarks The turbine is generally in good condition. The bent blades seem to have been caused by a piece of the Stearns meter which is missing. The groove due to rust steam. All shafts & bearings except governor shafts OK. Governor groove which needs renewing at next inspection. Oil pump bearing and shaft renewed this time, side clearance reduced to 0.001" Air pump rods renewed this time. Regulating valve ground in steam & oil. Vacuum breaker cleaned. Condensate pump completely repacked. All oil sight replaced with new oil. Carbon rings filed on ends to make close fit to shaft. Oil strainer renewed with 30 mesh wire cloth. Thick edges on governor ground to good edge. Governor shaft filed up smooth. Oil Cooling tubes cleaned and cooling tubes cleaned inside and outside.

convenient method is to add the readings at each point at both positions of the revolution together and take the mean as one reading, and from a study of these four dimensions the amount of misalinement can be determined.

It is a common practice not to make the coupling faces exactly parallel when the machine is cold; allowance must be made for the rise in temperature of the turbine as a whole and for a greater rise at the steam inlet end due to the greater heat of the steam at that point. In case of a turbine driving a pump, pumping hot feed water or liquids, this would not be so apparent, as where the driven unit is comparatively cold.

To take care of this condition, it is usual to set the turbine as a whole slightly low and the rear end a slight amount lower still. What this amount is, depends on the size and running conditions of the machine and must be determined on the spot but in any case is only a few thousandths of an inch. The center lines of the shafts may, however, be parallel to one another, yet not be in line. One shaft may be lower than the other. To check this, use the 6-in. straightedge on the diameters of the coupling at the four points as in the other test and if the couplings are both of one diameter, the straightedge should lie level on each coupling if in line. If it is not so, the shafts are not in line and must be moved until they are, making the allowance for expansion vertically as required. The claw type of clutch is not so convenient, as the claws need lubrication and consequently is guarded; this does not make it so easy to get the dimensions as in the pin coupling. To check this, if only three sides can be reached, a gooseneck piece can be fastened to one claw and brought close to the other claw sleeve. The measurements between the testing piece on one claw and the sleeve on the other claw should be the same at the three points obtainable if the shafts are in line in a horizontal or vertical plane. Dimensions obtained between claws at top and two sides, similar to the pin coupling, will determine whether the shafts are parallel. Sometimes in checking shafts for alinement, a thin sheet straightedge is used and it is often difficult to keep this true to the center line of the shafts and errors consequently accrue. The writer has found that a straightedge whose cross-section is L shaped when accurately made is helpful in such a condition as described.

Couplings are termed flexible, but this does not mean that they will run under any conditions for in spite of their being flexible a very few thousandths out of line will in time prove disastrous, even with pins running in rubber bushings. The alinement of a machine should, in all cases, be kept as near perfect as possible.

Inspection of piping, blading, governors and condensers will be discussed in a subsequent article.

Diesel Pumping Plant Shows Low Operating Cost

Cost of Pumping With Diesel Engines Is Lower Than With Motor Drive in Appleton Municipal Plant. By Arthur J. Hall

After nine years of experience with a Diesel engine pumping plant, in comparison with electric equipment which is at present used as an auxiliary, the water department of the city of Appleton, Wis., is thoroughly convinced that the Diesel plant is entirely suited for this class of work and will show lower operating costs than any other drive.

From operating records which have been maintained, of which the log sheet shown in Fig. 1 is an example, it has been found that the cost of pumping with Diesel engines is $19.35 per 1,000,000 gal. and with electric motors $62.70 per 1,000,000 gal. These costs do not include, however, the item of fixed charges, and since it is frequently stated that this item of expense is higher for the Diesel plant than other types drive, some explanation of this point is necessary.

In the case of the costs which were arrived at from the log sheet shown in Fig. 1 and the tabulation shown in the table, the item of fixed charges as applied to the cost of pumping per 1,000,000 gal. would hardly be fair to the electrical equipment since this drive is used merely as an auxiliary to the Diesel plant. In the interest of a fair presentation of the subject, an analysis of the fixed charges should be made on the basis of the proportionate part of the capacity of electric pumping to the maximum possible.

Including the items of depreciation, interest on the investment, insurance and other such items, the fixed charges on the Diesel plant are estimated to be $861.45 a month. On the same basis, the fixed charges on the electrical equipment are $111.46 a month.

In December the Diesel plant pumped 41,830,000 gal. of water in 448 engine hours and the electric drive 2,670,000 gal. in 29.5 hr. On the basis of the same number of operating hours, the electric pump would have had an output of 40,000,000 gal.

If the fixed charges per 1,000,000 gal. pumped are figured on this basis, this item would amount to $2.79 for the electric drive and $20.60 for the Diesel drive. The total operating cost would be $65.49 per 1,000,000 gal. pumped for the motor equipment, as against $39.95 per 1,000,000 for the Diesel plant.

It will be noted that the charge for electric current amounts to approximately 5 cents per kw.-hr. since this is auxiliary service. Even if the power charge were reduced to 3 cents per kw.-hr., which is about the best that could be expected for a plant of this size, the operating cost for electric pumping would be reduced only to $48.99 per 1,000,000 gal. pumped, as against $39.95 for Diesel pumping, as previously mentioned. In this last case, also, the fixed charges for the electrical equipment are figured on a basis of 40,000,000 gal. pumped.

All of these items tend, however, to favor the electric drive since it is assumed that this pump is working at maximum capacity at all times, whereas the Diesel pumps are compelled to run under reduced capacity according to the demand for water.

Several of the items shown in the table appear to be low, but this is accounted for by the fact that this pumping plant is also run in conjunction with a filtration plant, and as a consequence, cost of superintendence, labor and heat are less than might be expected in

a plant when such items cannot be divided. These do not, however, affect the comparison shown between electric and Diesel drives.

While some figures might be given showing the comparison between the original steam pumping plant which the Diesel plant supplanted, these costs would be of no particular value since steam drives of a later type are far more economical. Even with modern equipment, however, it is doubtful whether steam pumps could compete with these costs, as the cost of banking boilers during the night hours would in itself add a considerable item to the expense. At the same time, labor and superintendence costs would be increased.

Originally the water works for the City of Appleton, Wis., was privately owned; but a few years ago, the city of Appleton purchased the plant for the sum of $250,000.00. The station was then composed of a 100-hp. non-condensing steam engine which was connected to two double-acting duplex pumps of 2,000,000 gal. capacity each. Water was supplied to the city by pumping directly into the city mains, with no means provided that would maintain the pressure at a fixed point at all hours, against a varying demand. The service was unsatisfactory and insufficient for either domestic use or for fire protection. Water containing 40,000 bacteria per cubic centimeter, of which a large percentage were sewage organism, was often supplied for domestic purposes.

This deplorable and inefficient service was corrected by the installation of a mechanical filtration plant for the purification of the water, an elevated distributing reservoir and a pumping station in which two 225-hp. Busch-Sulzer Diesel engines were installed. Each Diesel engine is directly connected to two Dean double-acting triplex pumps of 2,000,000 gal. capacity each. The two units are located opposite each other, in such a way that their shafts are parallel and the air compressors can be run from either engine. The pumps are located one on each end of each engine shaft.

Soon after the plant was put in operation it was found that the cost of lighting was excessive and two Allis-Chalmers 15-kw., 110-v., direct current generators were connected by chain drive, one to each engine, to eliminate this expense. The fuel consumption for the month after the generators were put into service was not advanced over the previous months. The power thus supplied is used not only for lighting the pumping station and filter plant, but also for operating the booster pump in the filter plant, and for three small motors in the pumping station.

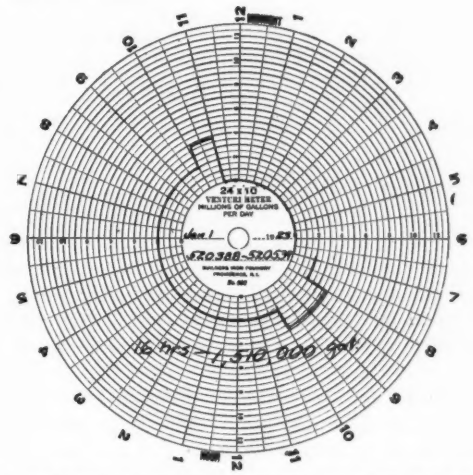


FIG. 2. RECORDING VENTURI METERS ARE USED TO MEASURE THE WATER PUMPED

Oil for the engines is stored in two 10,000-gal. steel tanks and a 20,000-gal. concrete tank located outside the plant, and is pumped to two small steel tanks in the engine room. From these tanks the oil feeds by gravity to the fuel pumps.

APPLETON WATER WORKS Monthly Log
PUMPING STATION FOR THE MONTH OF *November* 192 *2*

DATE	OIL ENGINES NO. 391 Hours Run	OIL ENGINES NO. 391 Gals. Fuel Oil	OIL ENGINES NO. 392 Hours Run	OIL ENGINES NO. 392 Gals. Fuel Oil	OIL PUMPS HOURS RUN By Engine No. 391 No. 1	By Engine No. 391 No. 3	By Engine No. 392 No. 2	By Engine No. 392 No. 4	ELECTRIC Pump No. 3 Hrs. Run	ELECTRIC Pump No. 3 K.W. Hrs. used	Water Gals. Pumped Oil in 10,000 gal. units	Water Gals. Pumped Electric in 10,000 gal. units	PINTS OF LUBRICATING OIL CYLINDER OIL	AIR COMP'R	ENGINE	KEROSENE	ELECTRIC MOTOR OIL	REMARKS
1	16	136			16	6					171				3	38		
2	16	126			16	4					160			2		18		
3	16	124			16	4					158		2			2		
28			15	116			15	3	1	93.80	143	9	14		3			
29									16	1558.26		145	14					
30			1	8			1		12.5	1293.75	11	113	2			2		
31																		
TOTAL	381	2926	67	518	381	75	67	14	29.5	2943.8	4183	267	272	18	24	232		

Total Oil Engines Hours Run 448 Hours
Total Gallons of Fuel Oil Used 3444 Gallons
Total Gallons of Water Pumped 41,830,000 Gallons
ELECTRIC—Total Hours Run 29.5 Hours
Total K. W. Hours 2943.8 Gallons
Total Gallons Water Pumped 2,670,000 Gallons

OIL—Average Hours Run Per Day 15.4 Hours
Average Fuel Oil Per Hour Operated 7.6 Gallons
Average Gallons of Water Pumped Day 1,442,000 Gallons
Av. Fuel Oil Per 1,000,000 Gallons of Water Pumped 82 Gallons
ELECTRIC—Average Hours Run Per Day 9.8 Hours
Average Per K. W. Hours 99 Gallons
Average Gallons Water Pumped Per Day 870 000 Gallons
Average K. W. Hrs. per 1,000,000 Gals. Pumped 1103 K.W.Hrs

Supt.

FIG. 1. IN THE APPLETON PLANT OPERATING DATA ARE RECORDED ON A MONTHLY LOG SHEET

Each engine is run every other week and during the time an engine is down it is inspected and any necessary adjustment made. The valves are ground about every 6 months and the engines are thoroughly overhauled once a year.

Each engine has its own muffler as it was found that when one muffler was used, a leaky valve would allow the exhaust gases to back up into the idle engine. Trouble was also experienced with these valves freezing in winter which made it necessary to house them. The use of separate mufflers relieved these minor troubles.

An oil of 26—30 deg. Baumé is used during the summer months and in the colder months a lighter oil of 30—34 Baumé is used.

In order to increase the reserve pumping capacity in case of fire and also as auxiliary service, a 2,000,000-gal. Dayton centrifugal pump driven by a 100-hp., 440-v. alternating current motor was recently installed. With this unit, the combined capacity of the station is 10,000,000 gal. per 24 hr.

During the time the plant is shut down, a 500,000-gal. standpipe located about ½ mi. from the plant takes care of the water requirements of the city. The water is pumped into the mains and the surplus backs up into the standpipe. Pumping at the station is so scheduled that at 11 p. m. the standpipe is filled and the plant is then shut down until 7 a. m.

As previously mentioned, a log sheet is kept which shows the details of plant operation and a venturi meter records the gallons of water pumped. This venturi meter chart could almost be used to indicate the fuel consumption of the Diesel engines, since their fuel consumption is so nearly proportionate to the productive load.

This plant has now been in operation 9 yr. and little trouble has been experienced other than the minor repairs which must always be made in any type of plant. The Diesel plant has been found to be efficient, simple and reliable.

COST OF OPERATION DURING MONTH OF NOVEMBER, 1922

Oil Pumping Power		Electric Power Pumping	
Superintendence	$125.10	Superintendence	$ 8.24
Labor	351.83	Labor	23.17
Fuel oil used	244.87	Electric power	132.65
Lubricants	28.50	Miscel. and supplies	3.06
Miscel. and supplies	47.41	Light, heat	.29
Light, heat	4.39		
	$802.10		$167.41

System in Scrapping the Obsolete

VARIOUS METHODS used by manufacturers in determining when commodities they produce should be dropped as obsolete, are set forth in a bulletin just issued by the Fabricated Production Department of the Chamber of Commerce of the United States.

Obsolescence is one of our industrial problems dealt with largely in a haphazard way, or by rule-of-thumb practices, because its cost burden has not been fully realized. Undoubtedly it is valuable service to provide replacements during the natural life of a tool or piece of equipment and sometime longer, but when such service is too prolonged, the interests of both the seller and buyer are injured in thus keeping in use that which has outlived its economic usefulness. There is a line of demarkation between economy and waste which is not always easy to determine. No hard and fast rule can be applied, for lines differ essentially and so do conditions. Again the consumer's interests should be as carefully protected as those of the producer.

Some of the courses pursued by manufacturers of various commodities are suggestive.

Engines: "We did destroy a good many patterns that were 20 yr. old, feeling that if these people desired repair parts after the machinery had been in service this length of time they could afford to pay for making a new pattern. We also figured that most concerns would take at least 5 per cent depreciation a year and that therefore the machines, as far as their book value was concerned, would be wiped out.

"It is a hard matter to decide when the period of justifiable service ends. It would seem to the undersigned that it might end at the time a reasonable depreciation would wipe out the cost of the article."

Pumps: "Patterns are destroyed on recommendation of the works manager to the office and on approval by the vice-president in charge of manufacturing after consultation with the vice-president in charge of sales. We fix no limitation on the life of patterns, it having been our experience that some patterns may become obsolete in a short time while others would not.

"Patterns, jigs and fixtures of 15 yr. of age or more are to be destroyed when the records show no use of such patterns, jigs or fixtures over a period of 5 yr."

Electric Motors: "When a piece of machinery has been in service more than 10 yr. then, in general, the manufacturer is not obligated to continue to build stock repair parts for which there is such a small demand that they cannot be sold at a reasonable price.

"We are exceptionally careful that our line of goods is as small as possible, that changes in design contemplate the use wherever possible of such parts as have previously proven satisfactory in design, construction, etc., and are as good as new designs might be."

Boilers: "If we were asked to state how long a period patterns, jigs and dies should be kept simply for repairs to a line of tools which has become obsolete, we would say about 10 yr. If it is not possible to use our new design of pattern, we advise customer that the pattern has been destroyed and that we are making a new pattern to fill his order and will charge him only actual cost for it. Judging from cases in other plants, with which we are familiar, as well as in the case of our own plant, we think it is seldom that a manufacturer loses anything on account of scrapping obsolete material."

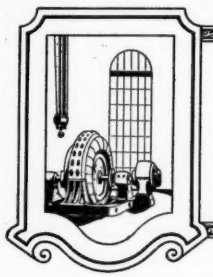
Summing up the methods, practices and experiences:

1. A system should be established in each industry to deal with obsolescence in lines produced and the equipment used in manufacturing them.

2. As a general rule the persons most competent to deal with the dropping of lines are: (a) General Manager, (b) Sales Manager, (c) Superintendent or Production Manager.

3. In discontinuing lines the points to be weighed most carefully are first, the protection of the consumer in providing for duplication of complete units and constitutent or repair parts based on a reasonable estimate of the life of an article after being put in use; and second, in justice to the producer the duration of such service should be considered from the standpoint of the burden or expense of maintaining it.

4. From an accounting standpoint, the treatment of obsolescence pertaining to patterns, molds, dies, jigs, etc., is not being dealt with independent of general depreciation. Consequently the rates warranted are not developed. It would seem, however, in the heavier lines a special study would be justified to determine more accurately the actual depreciation loss. In certain lines of engineering specialties the following typical depreciation rates are given: Dies, 7½ per cent; regular patterns, 10 per cent; special patterns, 33⅓ per cent.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operating Features of Generating Equipment---I

A Practical Discussion of Phenomena Involved in the Operation of Shunt Wound Generators. By V. E. Johnson

DURING THE past 10 or 12 yr., there has been a wonderful advance in the design and construction of electric generating equipment. The cranky, balky, direct current machine of old has been supplanted by a smaller, more compact and efficient machine and the low speed alternator by the modern high-speed turbo-alternator. While far more perfect, mechanically, the modern machine is more closely rated than were its predecessors, and as a consequence, more attention must be given the load conditions under which it operates. The successful operation of any piece of electrical equipment, however, requires a knowledge of the fundamental principles upon which it operates, and a discussion of the operation and maintenance of electrical equipment will, therefore include a discussion of these principles.

Direct current generators are classified in accordance with the arrangement of their fields—as interpole and non interpole, compound, shunt, or series. Under a different classification we can list them also as two-wire or three-wire. Series wound generators are obsolete in this country and will not be discussed.

Operation of Shunt Generator

In Fig. 1 is shown the diagram of a simple shunt wound generator. The rheostat R is connected in series with the armature A, and sometimes a field switch FS is connected in the circuit for the purpose of "killing" the machine while it is running. After the generator has once been operated, the field poles retain sufficient magnetism to build up the voltage to the desired value at any subsequent time. The small current set up in the field by the residual flux will, if the connections are right, pass through the field winding in such a direction as to strengthen the magnetism, and so by a cumulative process bring the field flux and hence the voltage, up to normal. This is a very simple phenomenon, and one with which engineers in general are familiar, but there is one vital point in connection with it which is sometimes not understood. In order that the machine may build up, it is essential that the field current resulting from the residual magnetism pass through the field circuit in such a direction as to aid or boost the magnetism. The direction of the residual flux in the fields being fixed, having been determined by the initial magnetization, it is evident that for a given direction of rotation of the armature, one connection only of field terminals to the armature leads, will cause the building up process to take place, a reversal of the leads resulting in a failure. If the field connection is correct for right-hand rotation, it will not work for left-hand. Usually the diagrams which accompany the machines from the factory show the lead arrangement for either rotation, but these instructions sometimes become mislaid, and the engineer is compelled to work out the proper connection.

To begin with, the field current set up by the residual magnetism is very feeble. Even a comparatively small defect in the connections will at times introduce

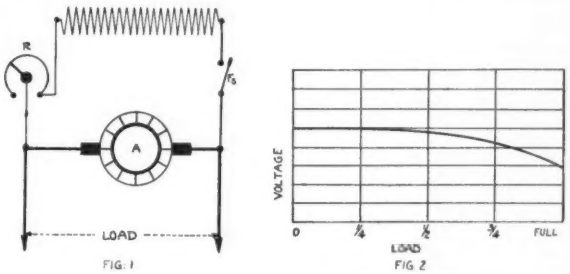


FIG. 1. SHUNT WOUND GENERATOR

FIG. 2. VOLT-AMPERE CHARACTERISTICS OF A SHUNT GENERATOR

enough resistance into the circuit to prevent a machine from building up. Also, it is in almost every case necessary to cut the field rheostat "out," at the start, in order to permit a maximum initial current to flow through the field circuit. On very low voltage machines, such as are used for electrolytic purposes, it sometimes happens that even the slight glaze under the brushes is sufficient to prevent a "build up" after the machine has been idle for a time.

In a shunt wound machine the voltage varies directly with the speed and the field strength. The field strength varies with the position of the field rheostat, and can be adjusted within fairly wide limits. With constant speed, the voltage of a shunt machine remains constant at no load, but the application of load causes the voltage to drop, due to the reaction of the current in the armature coils. Figure 2 shows approximately how the voltage of a shunt machine drops off under load conditions. If it is necessary to maintain constant voltage, it would be necessary to resort to external means of regulation. Either the rheostat would have to be adjusted or else automatic regulation would have to be resorted to.

It is obvious that with an external circuit of fixed resistance, the amount of current flowing from the generator can, to a large extent, be controlled by the field

rheostat. Only at the extreme end of the saturation curve does this rule fail, for here the iron is "saturated," i. e., filled with magnetism and additional field current produces no effect on the generated voltage. It is evident, too, that decreasing the resistance L will increase the load; as this process is continued, the armature reaction will reduce the terminal voltage, so that in time the increments of current for changes in L become smaller and smaller. For example, if the load resistance L be reduced to approximately zero the current does

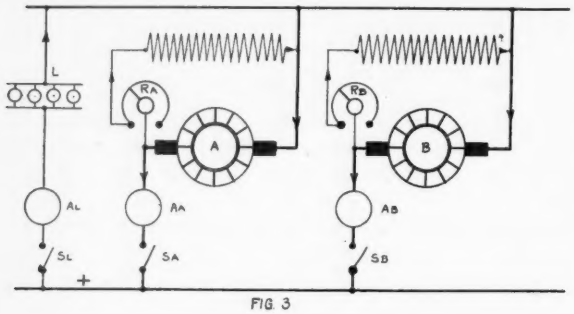


FIG. 3

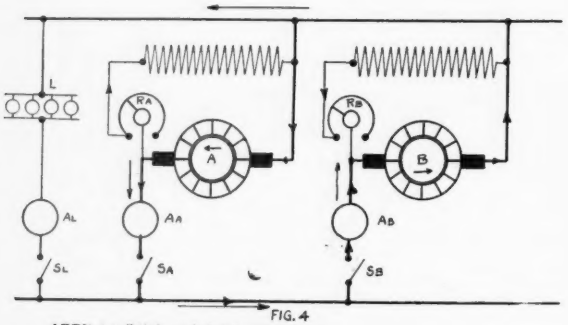


FIG. 4

ARROW HEADS INDICATE POLARITY
THIN ARROWS INDICATE DIRECTION OF CURRENT

FIG. 3. TWO SHUNT GENERATORS CONNECTED TO A COMMON BUS

FIG. 4. TWO SHUNT GENERATORS, ONE WITH POLARITY REVERSED

not rise to infinity; instead, the generator drops its voltage to nearly zero and so automatically unloads itself.

Parallel Operation

These two facts have considerable bearing on the action of direct current machines operating in parallel. In Fig. 3 is shown a diagram of two shunt generators connected to a common bus. The arrow heads indicate the polarity of each machine, i. e., the normal direction in which current would flow when load is applied.

Let us disregard for the moment that part of the circuit marked L and consider only the two generators. It is clear that if the negative terminals of the machines be connected to the upper bus—and the two generators, by means of rheostat manipulation, be adjusted to have the same voltage, no current will flow between them when the switches S_a and S_b are closed. If, through error, the polarity of one machine was wrong, as in Fig. 4, it will be seen at once that closing the switches S_a and S_b will cause a voltage equal to the sum of the generated voltages of A and B, to be impressed upon a circuit whose resistance consists only of the internal resistance of the two armatures and of the interconnecting leads and bus bars. The result of an attempt to operate in this manner would likely prove disastrous.

Returning now to Fig. 3, let us consider what would be the effect of raising slightly the voltage of one machine, for example, A. Current would immediately flow as indicated in Fig. 5, and would be limited in amount by the difference in voltage between A and B and the resistance of the interconnected armatures, and their connecting leads. This differs from the condition of Fig. 4 in that in the former the voltage impressed was the sum of the generated voltages, whereas in the latter case the voltage impressed on the closed circuit is the difference between the generated voltages.

It will be noted that although the current in B is flowing in a reserved direction the current through the field winding continues in its original direction. This, while seemingly unreasonable, is clearly seen when one considers that the fields are virtually connected from bus to bus and that as long as the (+) bus is of a higher potential than the (—) bus the current will flow as indicated.

At first thought it would seem that a condition of operation such as indicated in Fig. 3 or Fig. 5 would be very unstable. The armatures and bus bars have almost negligible resistance so that apparently even a very small movement of the field rheostats would cause a dangerous current to flow. This, however, is fortunately not the case. The current which flows through the closed circuit in Fig. 5 establishes an equilibrium in the circuit by the demagnetizing effect of the armature current flowing in A, and by the magnetizing effect of the same current flowing through B. In other words, the flow of current itself tends to reduce the voltage of the "high" machine and at the same time raises the voltage of the "low" machine—thus establishing a balance.

It can readily be seen that with connections as in Fig. 5 the amount of current circulating between the machines can be controlled very easily. If, then, in Fig. 3 the switch S_l be closed on a circuit having an adjustable load L, current will flow through this in accordance with Ohm's law. If the two generators A and B be adjusted so as to give equal terminal voltages, each will supply half of the current in the circuit L. Thus,

$$A_a = A_b = \tfrac{1}{2} A_l$$

where A_a, A_b and A_l are the ampere readings of A, B, and the load L respectively. By raising the voltage on A it is possible to make $A_a = A_l$ while $A_b = 0$. In other words, in that case the generator A is doing all the work and B is merely floating on the line. Or, by raising A's voltage still higher, it can be made to supply all of the load current and in addition pass current through B in a reversed direction driving it as a motor. In that case

$$A_a = A_l + A_b.$$

Without further discussion, it is evident that by rheostatic manipulation of the two machines either generator can be made to carry any desired proportion of the load L and either machine can, at will, be run as a motor. "Motoring" a shunt wound generator does no harm in itself, but such operation is usually accompanied by sparking, and, if the current flow is sufficient, may result in a flash over at the commutator. Obviously such operation is undesirable, even if not destructive.

Having established the possibility of controlling load division by means of the field rheostats—let us consider the result of varying the load L—leaving the rheostats in the position of "equal voltage" as determined at no load. If A and B are similar machines, and are driven by prime movers of similar speed regulation, and have their brushes set in similar positions with respect to neutral, the load characteristic curve, as shown in Fig. 2, will be practically identical for each machine. As a result, throughout the limits of loading, the two generators will "droop" an equal amount, and at any point the generated terminal voltage will be the same. The load will be divided equally throughout without rheostat manipulation of any kind. As previously stated, however, the drop of voltage due to load would usually not be permissible, so that the attendant would be compelled to strengthen both fields as the load increased—not to divide the load, but to maintain the voltage.

Effect of Dissimilar Characteristics

If A and B are dissimilar machines, or if for any reason their load characteristics differ, as is the theoretical case in Fig. 6, then load division will not be correct for varying loads. It will be seen from these curves that at ½ load the voltages are equal, at ¾ load B is lower, while at full load A is lower. In such a combination of generators, the load would swing first to A and then to B. To maintain an equal division of load would require rheostat manipulation.

In the dissimilar characteristics of machines of different ratings lies one means for dividing the loads between them, not equally, but in proportion to their capacities. This becomes plain when one considers that for a given load a small machine is nearer its rated capacity than is a larger machine, and that therefore its curve has drooped lower. This can be seen in Fig. 7, which shows curves of two machines, the curves having the same general outline. It is apparent that the smaller machine will drop off some of its load much quicker than the larger one—which is as it should be. At the point corresponding to full load on the small machine, the larger one is operating at about half load.

From this is can be seen that machines of unequal ratings, in a measure, automatically proportion the loads between them. The characteristic curve of a shunt wound generator is to a large extent determined at the factory, but it can usually be changed to some degree in the field. In making such changes, care must be taken to avoid confusing voltage drop due to generator regulation, with voltage drop due to prime mover regulation. It often happens that a bad drop in voltage is due to the engine slowing down under load, and not to poor generator design. This point should be carefully checked.

A simple way of changing the shape of the load curve of a shunt wound generator is by "rocking" the brushes forward or backward by means of the brush shifting device. On interpole machines, the amount of movement possible is very little (sometimes no movement at all is permissible), but on plain shunt wound machines considerable latitude exists. This is particularly true of old machines which were very liberally rated.

In Fig. 8 is shown a portion of a commutator with the neutral point N indicated by an arrow. With clockwise rotation the brushes may be set at "no load" anywhere between the points N and B, while at full load they may be set anywhere between A and C. Thus the zone A-B is satisfactory for both no load, and full load operation, and between these limits commutation will be satisfactory throughout the entire operating range. In some machines, the zone A-B is very narrow—in fact it may be only a point—while on others it is quite wide. If commutation permits it the load curve of a generator can be "straightened out" by moving the brushes nearer the "trailing" limit A of the commutating zone; and on the other hand, the droop can be increased by moving the brushes toward the "leading" limit B of the zone.

There is not space in an article of this kind to explain in detail the reason for this phenomenon. Later on, under the subject of "commutation," the matter is discussed briefly. It is, however, a very simple method of adjusting the load characteristics of a machine.

Another method of changing the curve is to vary the reluctance of the magnetic circuit by changing the length of the air gap between the armature and the field poles. This is done by removing or inserting "shims" between the root of the poles and the yoke. This method is, however, a good deal of a "gamble" as very often a reduction of the air gap results in destructive sparking.

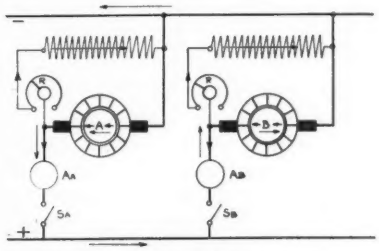


FIG. 5

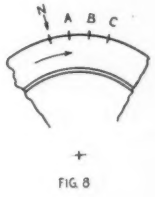


FIG. 8

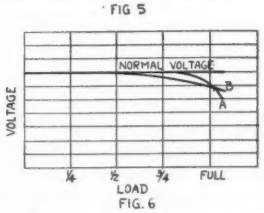


FIG. 6

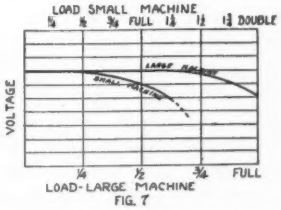


FIG. 7

FIG. 5. EFFECT OF RAISING VOLTAGE OF ONE MACHINE SHOWN IN FIG. 3

FIG. 6. CURVES OF TWO SHUNT MACHINES WITH DIFFERENT CHARACTERISTICS

FIG. 7. CURVES OF TWO GENERATORS OF DIFFERENT SIZES

FIG. 8. PORTION OF COMMUTATOR SHOWING NEUTRAL POINT

The Cost of Lighting

This should be the last thing considered, especially in such lines as employ high-priced labor, or use expensive material, and where insufficient or unsuitable lighting is liable to cause delay or error.

One 100-w. lamp, 1000 hr. a year, costs about $7 in most places. With labor at only 50 cents an hour, 8-hr. days, 300 days a year, that is under 0.6 per cent (0.6 of one per cent) of one man's wages. One such lamp per man would hardly be a ruinous expenditure, so it would hardly do to skimp on this item.

Robert Grimshaw.

Static Condensers for Power Factor Correction

LOSSES DUE TO LOW POWER FACTOR CAN BE ELIMINATED BY INSTALLATION OF STATIC CONDENSERS. BY R. E. MARBURY

FOR the economical delivery of power over transmission lines, it is desirable to maintain good power factor. When power is delivered at low power factor, the line current and consequent line loss is unnecessarily high and the voltage regulation poor. Due to the high line current, the power distributing capacity of the system is lowered and the investment for lines, transformers, generators, etc., is high per kv.a. of power delivered. Expense is also incurred due to the necessity of installation of voltage regulators to take care of the high line drop.

The inefficiency of this low power factor condition is illustrated by the following tabulation of line current for a single-phase, 550-v. load of 75 kw. having various power factors.

Per cent power factor.....	100	90	80	70	60	50
Current	136.3	151.5	170.5	195	228	273
Kv.a.	75	83	94	107	125	150

This increase in line current is due to the wattless component caused by magnetic fields, which lags behind the voltage by 90 deg.

Many power companies have encouraged the maintenance of high power factors by an establishment of rates that take into account consumer's power factor. This takes the form of a bonus for power factors above and a penalty for those below a certain value. One power company is selling power in line with a system such as illustrated in Fig. 1. Others specify the minimum power factor that will be tolerated.

CORRECTION WITH STATIC CONDENSERS

SINCE the static condenser takes a charging current which leads the voltage by 90 deg. it has opposite characteristics to an inductive device. Thus, when a static condenser of proper proportions is connected in parallel to an inductive load, the stored electrostatic energy in the condenser supplies the magnetic energy in the motor, and vice-versa, and the power factor of the combination becomes unity. The wattless current then circulates through the local circuit formed by the motor and condenser and does not have to be supplied over the line.

As shown in the table, a 75-kw., 550-v. load having 50 per cent power factor would take a current of 273 amp. If this power is delivered over an appreciable distance, the line loss would be excessive. If a static condenser of 130 kv.a. is connected across the line at the motor, the current in the line is reduced to approximately 136.3 amp. or 50 per cent. The current in the portion of the line between the condenser and the motor, and the power factor of the motor remain the same.

FUNDAMENTALS OF DESIGN

VARIOUS DIELECTRICS differ in their capacity to store energy in the static field, and a measure of this characteristic is the specific inductive capacity. This is merely the ratio of the energy stored in the dielectric in question to that stored in the air under identical conditions.

Fibrous insulation impregnated with mineral oil has a specific inductive capacity of 2.5 to 3. The stored energy varies as the square of the voltage which creates the field, as well as with the S. I. C. Power for the energy flow into a condenser varies as the rate of flow, or in alternating current systems with the frequency, and with the energy of the field. Thus, the kv.a. or reactive power varies as the square of the voltage per unit thickness of condenser dielectric and directly with the S. I. C. (standard inductive capacity) and frequency.

In the development of condensers the first step is selection of materials, then the establishment of the working stress, then the design. Although some materials have higher S. I. C., investigations have shown that all things considered, paper and mineral oil are the best and with them, losses as low as one-half of 1 per cent are obtained commercially. After standardization of the

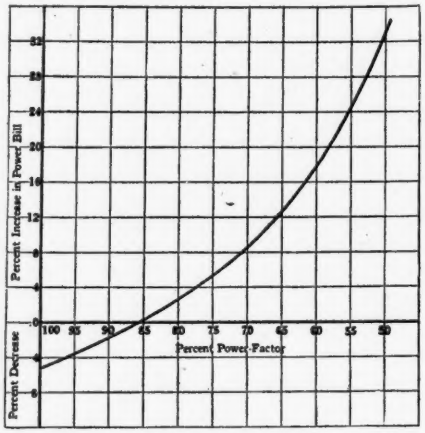


FIG. 1. EFFECT OF POWER FACTOR ON A POWER BILL

This curve is based on a fixed rate per kw.-hr. The per cent increase in power bill per kilowatt varies with the power factor of the load. For higher than 85 per cent power factor a bonus is realized.

material, the remaining variables in design are frequency and voltage stress, the frequency being established by the local requirements.

Since the kv.a. per unit volume varies as the square of the voltage stress, the extreme importance of a careful investigation of factors of safety, and their effect on performance and life is immediately realized. All the experience in the electrical art has contributed to the formulation of tests for insulation, and to establish the factors of safety required for reliability; and the volume of successful electrical apparatus that has been manufactured in line with these established factors of safety demonstrates their soundness. These factors of safety form a margin between the operating stress and the breakdown voltage. Such a margin is required for two reasons: First, the breakdown point may change with time, due to climatic conditions, heat, vibration, etc.; and second, line surges and accidentally applied voltages in excess of line potentials must be anticipated.

Insulation in static condensers is worked under very much more favorable conditions than in most other apparatus, in that it is well protected from moisture or mechanical injury. By highly refined treating processes, the losses are made very low and the temperature rise only a few degrees. This creates the tendency to work at very reduced margins, and tests seem to justify such

a course. Although the experience to date with condensers has given indications that margins very much smaller than normal may be permissible, the reduction, if any, will be established only through long years of experience under these more favorable operating conditions.

Factor of Safety Adopted

Due to line surges and accidentally applied voltages in excess of line potential, such as occur with all apparatus for this class of service, high factors of safety have been standardized on, for the type of condensers shown in Fig. 2, and the favorable conditions under

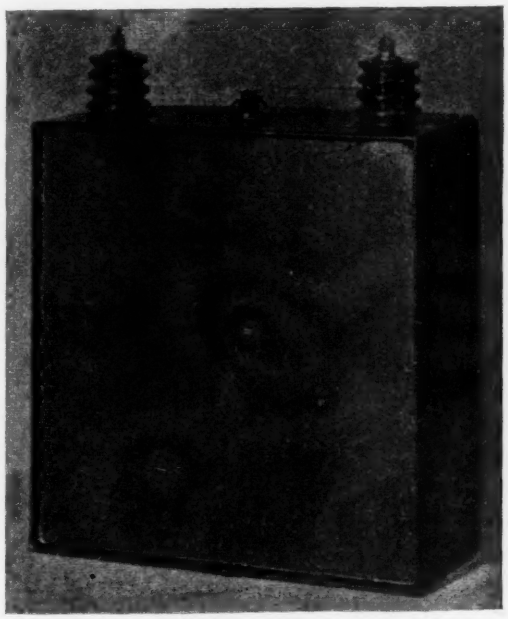


FIG. 2. TWO-KV.A., 60-CYCLE, 1328-V. STATIC CONDENSER UNIT

which the insulation is operated have not been used as a reason for decreasing margins of safety. All these units are tested at 2.25 times normal operating voltage plus 2000 for 1 min. This margin of safety places this apparatus on the same basis of reliability as other electrical equipment, and the overall space taken up is very little greater per kv.a. than for transformers or similar apparatus.

Application to Circuit

Due to the fact that the maximum benefit is derived from a given condenser kv.a. when it is installed directly across the motor it might seem that this should be done. However, this is usually undesirable, because the unit size becomes small, the mounting cost per kv.a. high, and the circuit voltage at the motor is generally low. There is such a large ratio between the cost per kv.a. of static condensers for 1328 to 2300 v., and for lower voltages, such as 220, 440 and 550, owing to limitations in material, that it is more economical to design them for the higher voltages and step up their voltages with transformers. Grouping the condensers into one large installation is also more economical, even though slightly more kv.a. capacity may be required sometimes due to the length of line between the condenser and the motor having low power factor. This last difference, however, is very small in most cases, and hardly worth taking into account, except where the motors are installed at considerable distances apart.

Capacity required in group installations is decreased by poor load factor, since the kv.a. required to correct the average load is less than that required to equip all the motors installed so as to have good power factor when running. When power is distributed to the plant at 2300 v. or above, the first cost of the condenser is still less, since the transformer for the condenser is not required and the latter is connected directly to the line.

For flexibility of application the condensers have been made in 2 kv.a. units for 1328 v., 60 cycles. For two-phase application, they are of the same size and kv.a., but designed for 2300 v. These two types of units, connected in various ways, are applicable to practically all standard voltages above 2300.

The units shown in Fig. 2 consist of many laminae of insulation separated by thin metal plates, impregnated and filled by a special vacuum process with oil. They are enclosed in hermetically sealed sheet steel containers and the leads are brought out through a tapered insulator which is oil tight and which will not permit moisture to get into the condenser case. These 2 kv.a. units are assembled in structural iron framework and enclosed by metal screens. An automatic circuit-breaker is mounted on the front of the frame for switching the condenser. Discharge resistances are connected in parallel with the condenser at all times so that it will be discharged quickly after the circuit-breaker is opened, to eliminate danger to the operator when handling supposedly dead circuits. Where groups of such frames are mounted together, only the main frame is equipped with an automatic circuit-breaker while the others are provided with inexpensive oil switches. The corrective kv.a. may be easily changed by means of these oil switches to take care of daily variations in load conditions. For seasonal variations in load, small jumpers are placed on the bus bars so that any one of the units in the frame may be disconnected, thus varying the connected kv.a. of the individual assembly.—Electric Journal.

Dynamos on the Dead Sea

Plans for the electrification of Palestine by raising the level of the Sea of Galilee and harnessing the historic River Jordan, involving an initial expenditure of $10,000,000, are described in "Palestine—Its Commercial Resources with Particular Reference to American Trade," by Addison E. Southard, American consul at Jerusalem, just published by the Department of Commerce. The same project calls for the canalization of the Jordan Valley from the Sea of Galilee to the Dead Sea, where under irrigation, it is expected that copious crops of dates, rice, sugar cane, flax, and cotton can be produced. Provision for 2000 mi. of motor highways, commercialization of the Bagdad-Cairo air route, traversing Syria, and agricultural credit banks are among the other innovations contemplated in the modernization of the Holy Land, as related by Mr. Southard.

A rust preventive consists of a mixture of white lead and tallow.

Interconnection of Transmission Lines in Ohio

IF PROPOSED INTERCONNECTION IS CARRIED OUT, POWER MAY BE TRANSMITTED FROM CHICAGO TO PHILADELPHIA. BY C. E. REESE

PUBLIC UTILITY as a whole, and more especially the electric light and power utilities, have reason to view the developments of the past year with more satisfaction than any other recent year. The bond market has steadily widened and the cost of money has steadily declined. Further recognition of utility securities as entitled to classification as prime investment securities has steadily widened. Growth in sale of junior securities to customers of the various companies has been very rapid and this method now offers a field for financing a considerable portion of construction requirements. There is more construction work under way being planned than at any previous time and the coming year will witness an unprecedented expansion of utility facilities generally.

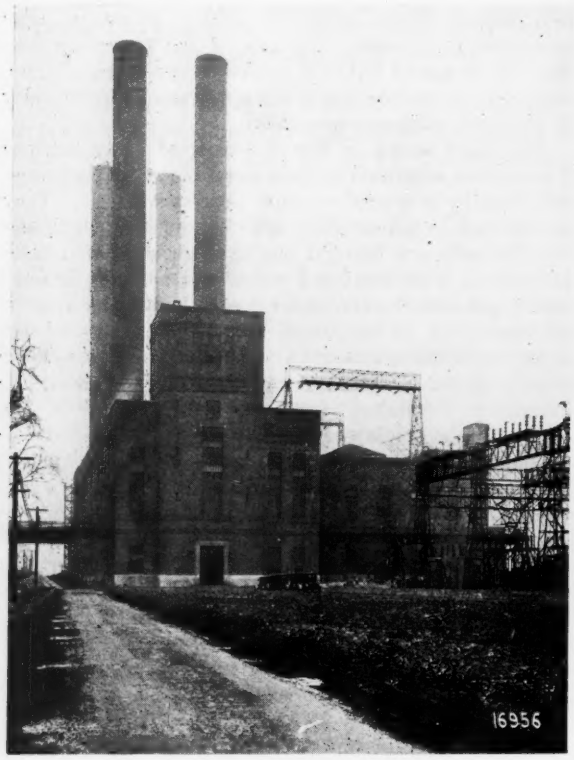


FIG. 1. CHESWICK STATION OF DUQUESNE LIGHT CO. IF PROPOSED INTERCONNECTION IS CARRIED OUT, POWER GENERATED IN THIS STATION MAY BE USED IN CHICAGO

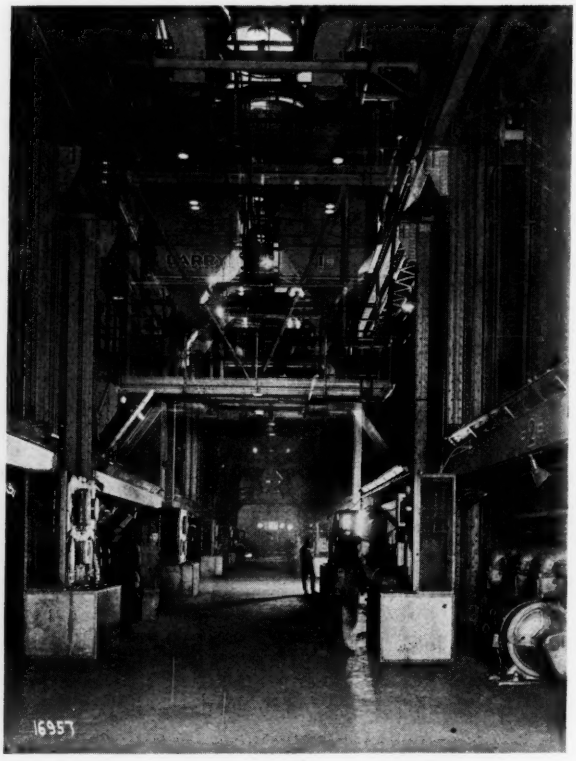


FIG. 2. BOILER ROOM VIEW IN THE CHESWICK STATION. EACH OF THE 2290-HP. B.W. BOILERS IS FIRED WITH A WESTINGHOUSE STOKER

PUBLIC IN CONTROL

PUBLIC REGULATION is more firmly established than ever before and has had a healthy growth. The regulatory commissions to-day recognize that completely satisfactory service is the prime requisite for public satisfaction and that such service can be rendered only when rates are adequate to yield sufficient return on investment to attract new capital in the competitive markets for investment funds.

NEW CAPITAL REQUIREMENTS

WHILE THE development of utilities as a whole was greatly retarded through the war period, they demonstrated at that time such stability that with the return of rental on capital to a basis which regulated utilities can pay, they are now in position to enjoy unprecedented growth. It is estimated that the entire electric utilities will require between $750,000,000 and $1,000,000,000 annually over the next 5 yr. to catch up to their normal development in proportion to markets. It is also the belief of the industry that this vast sum can and will be raised.

NEW INTERCONNECTION IN OHIO

AT TOLEDO the Toledo Edison Co., a Cities' Service Co. subsidiary, is building a 66,000-v., three-phase, 60-cycle line from the Acme Station in Toledo, to connect with the American Gas and Electric Co.'s transmission system at Pemberville, Ohio. The new line is of wood pole construction and carries three 4/0 stranded copper conductors, also a No. 8 copper weld telephone line. In the construction of the line, there is being used for probably the first time in that part of the country, fabricated galvanized steel cross-arms, brazed with the braces at the top instead of the ordinary practice of

bracing the arms below the arm. The spans are approximately 200 ft. in length, except at road, railroad or signal line crossings. The capacity of the present single circuit line is in the neighborhood of 18,000 kv.a.

As the new line is to supply 60-cycle power, and since the greater part of the Toledo Edison Co.'s generating equipment consists of 25-cycle apparatus, it was necessary to secure additional conversion equipment. There has been purchased, and is now being installed at the Acme Station, a 9000-kv.a. frequency changer which will convert the 6600-v., 25-cycle generation at the Acme Station to 6600-v., 60-cycle. There will also be installed at the Acme Station an outdoor sub-station, equipped with 15,000-kv.a. water cooled transformers, which will take care of stepping up the voltage from 6600 to 66,000 v.

At the present time the outlet from the Acme Station is on the towers of the new Belt Line, on which the circuit is carried to the point where the belt line crosses the Hocking Valley Railroad, from which point the circuit will be carried parallel to the Hocking Valley Railroad to Starr Ave., and will run parallel to the Terminal Railroad from Starr Ave. to Walbridge, Ohio. After leaving Walbridge, the line will again parallel the Hocking Valley Railroad as far as Lemoyne, and from the latter point, will extend due south to inter-connection point with the American Gas and Electric Co.

In order to get some idea of the territory served by interconnecting transmission systems, it might be well in this case to mention that the American Gas and Electric Co. from its plant at Wheeling, W. Va., is connected with such companies as The Duquesne Light Co. and The West Penn Power Co., and are inter-connected and serve territory as far east as Philadelphia, Pa.

The American Gas and Electric Co. is now building a new plant at Zanesville, Ohio, which plant will probably be connected at its Windsor plant, and it is possible that it will also extend its lines west into Indiana, to supply its properties. If the foregoing is accomplished, the Toledo Edison Co. will be a factor in the network of transmission systems that will supply electric energy from Chicago to Philadelphia.

Health Problems in Industry---III

FATIGUE AND ITS FACTORS; INDUSTRIAL MEDICAL SERVICE. BY DR. C.-E. A. WINSLOW

STUDIES OF industrial fatigue which have been conducted during recent years have introduced a wholly new point of view in regard to the question of the planning of the hours of labor. According to the older view, it was to the immediate interest of the employer to make the working day as long as possible, and to the interest of the employe to make it as short as possible. It is true that certain individual industrial establishments in Germany, Belgium and England have reported that shortening of the working week had been accompanied by an actual increase in production. It was only the experience of England during the war, however, which attracted general attention to this problem.

In the earlier days of the war, all the earlier English restrictions on the length of the work-day were abolished in the supposed interest of production and a working-week of 90 hr. was not infrequent in certain essential industries. The results, from the standpoint of production, were so unsatisfactory that a special commission on the health of munition workers was appointed and this commission soon reached the conclusion that too long a working period might actually decrease production by producing a condition of physiological fatigue which made efficient work impossible. These results have been amply confirmed by investigations of the United States Public Health Service in this country; and we now know that, in certain industries, the proper regulation of the length of the working day may be a very real factor in productive efficiency.

It is obvious that in many industrial processes this problem of fatigue as a limiting factor in production does not exist. Where the speed of a manufacturing process depends almost wholly upon the action of machines, as in certain textile operations, a 9-hr. day will produce 12½ per cent more than an 8-hr. day, irrespective of any human element involved. Even in processes where speed is determined by the human factor, there are many which call for muscular or nervous effort of a kind not resulting in fatigue which measurably decrease production. On the other hand, it is a real step forward in the science of industrial management to recognize that in certain processes of certain industries the regulation of a working day may not only prove beneficial to the employer, but may also directly increase productive efficiency.

It is not only the total working week which is important, but also its subdivision into working shifts. In processes where the fatigue factor is involved, the hourly production begins in the the morning at a subnormal level, rises rapidly as the worker "gets his hand in," then falls towards the noon hour as fatigue effects appear. After the noon hour, it starts on a level materially higher than that at which it stopped in the morning, rises slightly again and then falls sharply in the late afternoon. Professor F. S. Lee and the other investigators co-operating with the United States Public Health in the study of this problem have found that in certain industrial processes the introduction of a brief rest period in the middle of each shift may so materially reduce the falling off due to fatigue at the end of the unbroken shift as to cause a substantial net increase in production. In other industrial processes, no such increase in production occurs and it is evident that the relation between working-hours and production is a problem which must be studied in relation to each particular type of work and each particular group of workers.

Length of the working day is, however, only one of a number of factors which may influence fatigue and therefore production. Overheating of the workroom, as pointed out in an earlier article of this series, has a very definite effect of this kind upon productive efficiency as shown in a careful study of the tin-plate industry in England. Posture is another factor of primary importance. The arrangement of work-benches at a convenient

height and the design of seats, where work is performed in the sitting position, may make a substantial difference in production. It is impossible here to go into the details of the designing of factory seats, but the Safety Institute of America, 141 East 29th St., New York City, will be glad to put anyone desiring further information in regard to this point in touch with published studies or with experts who have investigated it.

Among the conditions which particularly favor industrial fatigue are (a) muscular strain, (b) nervous strain due to concentrated attention, (c) excessive speed and (d) monotony. Muscular strain may often be materially reduced by a careful study of the motions involved. The injuries that develop from lifting "tote-boxes" for example is often due quite as much to the shape of the boxes and to the extended position of the arms in carrying them as to their intrinsic weight. The writer recalls an instance where repeated strains experienced in setting buckets into a tank below the floor level were eliminated by the simple device of placing a bar at the proper point for the left hand of the worker to scure a support.

Fatigue due to concentrated attention and high speed is the type of fatigue which may often be expected to yield to the influence of brief rest-periods. Fatigue due to monotony can in some instances be controlled by a slight rearrangement of the process which will permit of a certain variation in activity. In processes which involve close visual attention, such as inspection work, a careful study of the problem of illumination will be likely to prove of significant value. Either a deficient illumination or an excess of glare may produce a material increase in the fatigue involved in any given process.

Industrial Medical Service

Among the most vital and important problems of industrial management today are the physiology and psychology of the operative. We have considered in this series of papers the more important ways in which conditions in the factory workroom can be so adjusted as to promote the health and the efficiency of the worker. The physician and the nurse are the experts employed to supervise and complete the system of health supervision,

Attention to accidental injuries is, however, only the first step in a system of industrial medical service. When once the expert assistance of the doctor or the nurse is available, it is quickly utilized in other ways, such as attention to minor illnesses. Here, as in the case of the accidents, prompt medical attention may often result in a material decrease of illness and absenteeism, although the factor of compensation payments does not enter in. In the case of illness, it is usually customary to give the first emergency treatment only at the plant hospital, since the illnesses in most cases have no connection with conditions of employment. It will always be well, however, to keep careful records of sickness rates by workrooms so as to detect any excess which may be due to working conditions. In the experience of the writer, most important and helpful suggestions as to desirable sanitary improvements have been obtained by a study of the records of the company hospital.

Where any specially hazardous or fatiguing processes are involved, the medical department should be utilized for the examination of all new men put to work in order to see if they are in physical condition to undertake the particular task in hand; and routine examinations should be made at regular intervals thereafter to detect any signs of damage to health as promptly as possible.

Where local conditions permit, it is highly desirable that all employes should be given a thorough medical examination at the time when they are employed, so that they can be assigned to work suited to their physical capacities, or not employed at all if there is no work in the particular plant for which they are fitted. An instance has been cited in an earlier paper of this series in which such a system of medical examination brought in a return of 160 per cent of its annual cost; and it is obviously as much for the good of the worker as for that of the employer that he should not be placed at a task which is likely to produce injury to his health.

Physicians and nurses, if they have fitted themselves for their task by special study of the problems of industrial hygiene, may be of great assistance in the study of the various problems of ventilation, lighting, dust hazards, poison hazards and general sanitation. Just as the safety engineer follows up every accident reported to see whether it could have been prevented, so the industrial physician should make a special investigation of conditions in any shop in which an excess of illness appears.

Finally, the physician and the nurse have an unusual opportunity for useful service as teachers of personal hygiene. Talks on such problems as dietary hygiene, ventilation of the sleeping room, exercise and rest should be given at intervals during the noon hour and the visit of each employe to the plant hospital should be made the occasion for a conference in regard to health habits. The organization service will, of course, vary widely with the magnitude of the industry. In general, one full-time physician and one nurse can care for 1000 to 1500 employes.

In a factory of several thousand hands, there should be a fully equipped plant hospital, with examining rooms rest-rooms, X-ray rooms and a corps of full-time physicians and nurses. In a plant of 1000 hands, a single physician and nurse will serve, and in still smaller factories the health needs of the employes may be met by a full-time nurse and a physician who comes to the plant for a few hours a day.

Considerable difference of opinion exists in regard to the relative value of full-time and part-time industrial physicians, but the writer believes that on the whole the full-time physician is likely to be most satisfactory because of the opportunity which such service offers of becoming a competent expert in industrial hygiene. For small plants which cannot possibly secure full-time expert service by themselves, a co-operative plan will often meet the difficulty, several factories combining to employ a physician who can divide his time between them, with perhaps a safety engineer and one or more nurses, all forming part of the common service unit.

It has been estimated that adequate industrial medical service can be provided at about $2 to $2.50 per employe per year, a sum which will be found to be small in comparison with the saving in compensation, in labor turnover, in absenteeism, and in efficiency, which such a service should effect.

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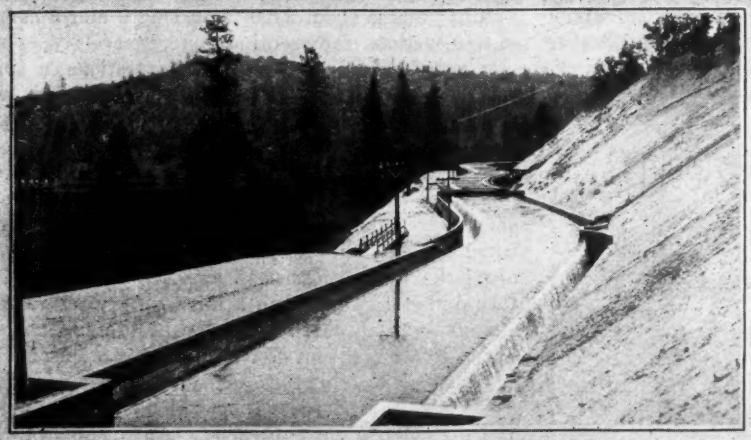
Novel Forebay at Hat Creek Plant Pacific Gas & Electric Company



Concrete forebay at the Hat Creek Plant of the Pit River Project of the Pacific Gas & Electric Co. There are two bays, one 180 ft. long, for plant No. 1, and one, about 500 ft. long, for plant No. 2. Concrete walls on both sides of the bay act as spillways. Water that spills over the up-hill side passes under the bay and is discharged down the hill through a concrete ditch.

Down stream view of the bay taken from the wooden flume shown in the above illustration. The under flow from the up-hill spillway is shown more clearly perhaps in this view. It mingles with the overflow from the down-hill side and is discharged into the ditch shown at the right hand side of the picture.

Another view of the forebay showing the valve house and transmission towers in the background. The forebay is unusually small, having a capacity of only 12.5 acre feet. It is, however, sufficient for the purpose as both the load and the flow are practically constant.

New Hydroelectric Development at Big Falls

DEVELOPMENT OF POWER SITE ON THE FLAMBEAU RIVER IN NORTHERN WISCONSIN MAKES 10,000 KV.A. OF ENERGY AVAILABLE

ELEVEN MONTHS after construction was started at the site, the first unit of the new hydroelectric station at Big Falls on the Flambeau River, Wisconsin, was placed in operation Jan. 15, 1923. This plant, which has a number of rather unusual and noteworthy features, was designed and constructed by the L. E. Myers Co. of Chicago, for the Lake Superior District Power Co. This new development will tie in with other

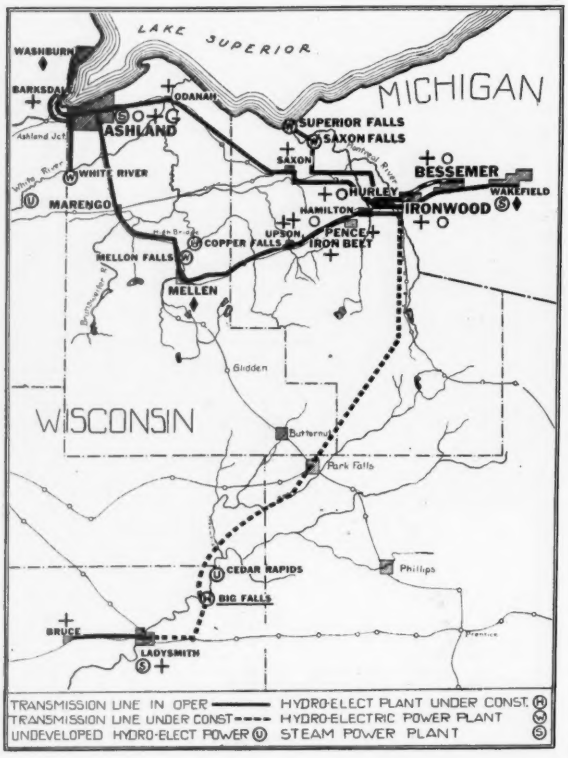


FIG. 1. SECTION COVERED BY THE LAKE SUPERIOR DISTRICT POWER CO.

properties of this company which serves a territory in northeastern Wisconsin and northwestern Michigan extending about 70 mi. along Lake Superior and containing the iron mining district known as Gogebic Range. Four other stations on other rivers in this territory are now in operation. With the addition of the new station it is estimated that about 85 per cent of the load will be handled by water power. Previously about 50 per cent was supplied from this source.

Big Falls, the site of the new development, is in the virgin forests of northern Wisconsin, just northeast of the city of Ladysmith, as indicated on the accompanying map. It consists, really, of a series of three falls and rapids having a total drop of 40 ft. within a run of about ½ mi. Stream flow records available for about 6 yr. show the flow to vary from a minimum of 800 sec. ft. to a maximum of 11,000 sec. ft. Because of the short duration of flow records it was considered advisable to provide for a flood capacity of approximately twice the recorded maximum, or 22,000 sec. ft. The head at the dam is 53 ft., which is sufficient to provide a storage of about 7,000,000 cu. ft. At normal flow this storage affects the stream for a distance of about 5.5 mi. above the dam and it is expected that it will provide an annual flow of about 1600 sec. ft.

Big Falls is about 2000 ft. in length and is composed of five sections representing four general types of design namely: two earth wing dam sections, a concrete bulk head section, a combined power house dam section, and an ogee type concrete dam with superimposed tainter gates as the spillway section. These types were chosen to take advantage of the favorable natural conditions and to reduce the cost of construction. On the west side of the river there is a bench which is almost level and which is about 500 ft. wide and approximately 41 ft. above the stream surface. There is rock close to the surface and it terminates in a hill to the west. The river channel was about 160 ft. wide at the site and had a natural fall of about 5 ft. A low rock bench 300 ft. in width existed in the east side of the channel about 15 ft. above stream elevation which was subject to partial overflow in times of flood. An abandoned channel about 180 ft. wide approximately 21 ft. above the surface of the water appeared as a boulder bed, separated from the stream by a rock knoll. Borings indicated this boulder bed to have a depth of about 12 to 18 ft. overlying rock. A gravel bench about 50 ft. above water surface underlain with gravel to a depth of probably 40 ft. extended eastward about 900 ft. and terminating in a high gravel hill. Excellent material for earth dam construction was available on each side of the river. This material consisted of glacial drift composed of well graded gravel, grading in size up to about one inch in diameter and carrying from 25 to 50 per cent of clay, allowing it to make a dense fill.

Comparative estimates indicated that the dam could be shifted up or down stream within a range of perhaps 200 ft. without material change in cost. The location at the foot of the rapids was chosen in order that the power house and dam might be built as one structure, thus avoiding steel penstocks about 200 ft. long which had been previously anticipated. The elimination of penstock cost was found to be sufficient to cover the additional cost of the dam at the lower site. The power house section was located just down stream of the rock bench east of the channel, as this location permitted excavation and construction of the substructure to begin immediately with the initial operation in February, 1922, and construction work on the power house to proceed without any interruption by spring season floods for which no diversion channel could be provided.

On the west side of the river there was rock bench which was best suited for the location of the cheapest spillway having the minimum erosion at the toe; however, this bench was too high to bring water to the spillway and carry it away freely without a reduction of capacity. The boulder bed east of the river channel was suitable for spillway purposes except that it was not long enough. There was adequate length for a

spillway rising a depth of 12 ft. on the crest across the river channel west of the power house. The adoption of this depth of overflow in order to concentrate the spillway in a relatively short length at the main river channel permitted an earth dam to be constructed across the boulder bed at a considerable saving in cost.

Each of the two earth wing dam sections is built with a top width of 16 ft. and a free board of 6 ft. at maximum water level. The upstream slope is 3 to 1 and the downstream slope 2 to 1. On the west side of the river, the earth dam is provided with a concrete wall about 3 ft. thick, built to about one-third the height of the dam where the dam is on exposed rock, but where built on earth footing, no sheeting or core wall is provided. Across the boulder bed east of the channel where the earth dam had a maximum height of about 36 ft. for sustaining a depth of water of about 30 ft., a core wall through the boulder bed is provided. The bulkhead section is of concrete construction with 7 ft. top and 32 ft. base set in a foundation channel excavated in the rock strata.

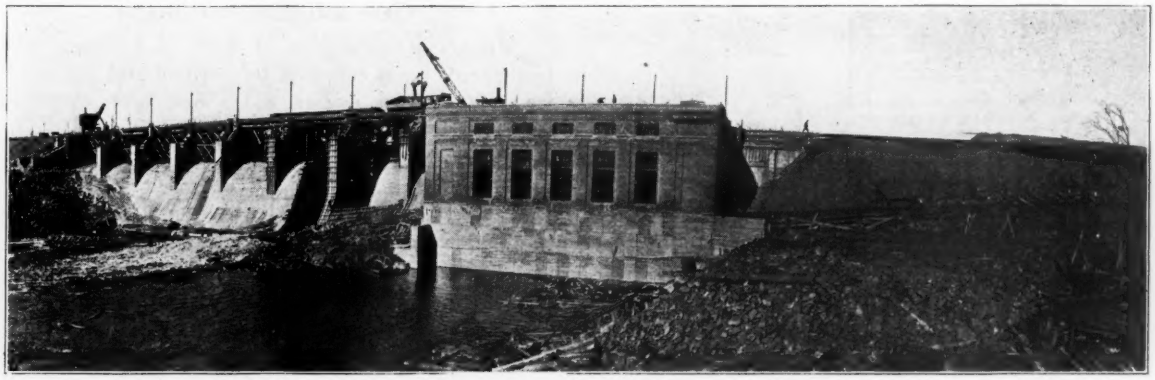


FIG. 2. DOWN-STREAM SIDE OF DAM AND POWER HOUSE AT BIG FALLS ON THE FLAMBEAU RIVER

As adopted, the spillway is 280 ft. in net length, designed for a depth of overflow of 12 ft. and divided into eight openings, each 35 ft. long, closed by tainter gates 13 ft. high, the extra foot in gate height being intended for free board. These gates are provided with two motor operated hoists, and are also equipped for hand operation. The hoists are mounted on a traveler frame running on the spillway super-structure. Duplicate hoists are provided to care for the disabling of a hoist during times of high flow.

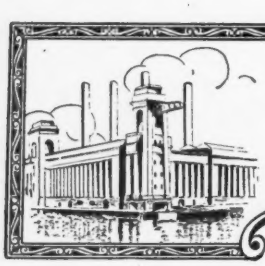
At the power house section, the dam and power house are built as one structure. The generator room is approximately 27 by 103 ft. and the electrical compartment is 20 by 103 ft., and is located between the buttresses of the head gate structure and generator room, directly over the penstock channels. Water for each unit is taken in through a 14 by 14 ft. opening with its center 27 ft. below normal water elevation. Each opening is closed by head gates built of structural steel with bronze bearing strips, sliding on planed cast iron guides inbedded in the concrete and hoisted by two 4½-in. screws extending to the operating platform above and operated by two interconnected, motor operated screw hoists which are controlled from the switchboard. A 2 by 2-ft. sluice gate is provided for bypass around each head gate for balancing the pressure, although the hoists are designed to operate the head gates under full water pressure. The penstocks are formed in concrete of ogee profile, changing from 14 by 14-ft. square section at the entrance to the circular section at the scroll case.

Draft tubes were designed on the results of tests upon 2-in. models of several suggested designs made at the plant of Wellman-Seaver-Morgan Co. This model of the adopted tube gave an efficiency of 68 per cent under test. The tube is a straight diverging cone for a distance of about 16 ft., at which point it enters an elbow spreading out rapidly in width, but with a small vertical height of throat.

Two G. E. 2300-v., 60-cycle, three-phase, generator units of 3300-kv.a. capacity driven by Wellman-Seaver-Morgan vertical single runner turbines devoloping 4000 b.hp. at a net head of 52 ft. are installed. A third unit is to be installed at a later date.

Exciters are of the direct connected type, mounted above the generator which is in turn mounted on a concrete pedestal about 5 ft. high. These units are governed by Woodward, type H.R. governors with motor driven oil pump. The governor actuators are located on the switchboard lever, as are also the hand oil pump for hand operation of the turbines. The platform on top of the generator is also located at the level of the switchboard floor and connected to it by a walkway. This brings the governor actuator, the governor hand operation, the inspection platform for generator thrust bearing, exciter brushes and collector rings all at the same level so that one attendant can observe, maintain and operate this equipment.

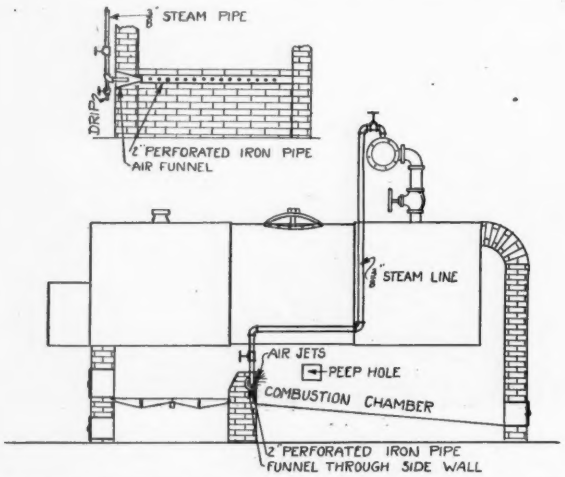
Leads from the generator units are carried in conduits installed in the concrete to the electrical control room. The 2300-v. oil switches, station power and light transformers, and bus bars are installed in compartments. High tension transformers and switching apparatus are located with high tension outdoor switching structural support built on a concrete platform adjacent to the power house. The high tension equipment is to operate at 88,000 v. Two three-phase transmission lines mounted on steel towers are now being constructed to connect this plant with the present transmission system of the Lake Superior District Power Company at the city of Ironwood, Wis., a distance of 88 mi.



LETTERS DIRECT FROM THE PLANT

Coal Saving Device

SOME YEARS ago I had charge of a plant furnishing light, heat and hot water to four apartment houses in New York City. While I was there permission was obtained of the owner by a French engineer to try out



HORIZONTAL RETURN TUBULAR BOILER FITTED FOR AUXILIARY AIR SUPPLY AT THE REAR SIDE OF THE BRIDGEWALL

a scheme he had devised to burn waste gases in the combustion chamber of a boiler, after they had passed, unburned, over the bridgewall. Accordingly, one of our boilers was let down, and this engineer put in his equipment. A piece of extra heavy 2-in. pipe, perforated with two rows of ⅜-in. holes, spaced 1 in. apart, was set in the rear side of the bridgewall, just under the top course of brick, with the perforations pointing to the shell of the boiler at an angle of about 45 deg., as shown in the accompanying sketch. A hole was cut through the side wall and a sheet iron funnel, 6 in. in diameter at its outer end tapering to fit in the end of the 2-in. pipe, was secured in the wall with cement.

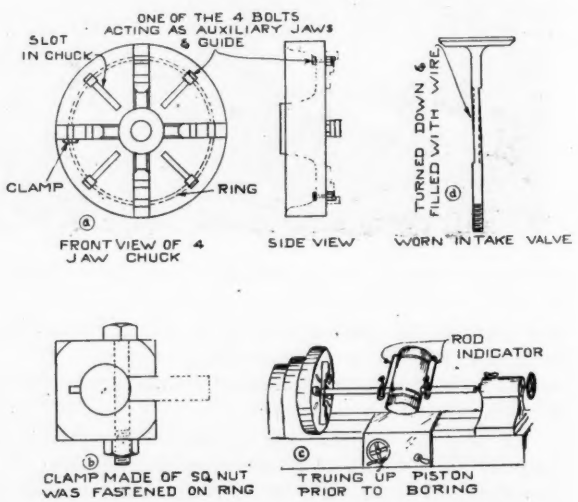
Dry steam was taken from the main line through a ⅜-in. pipe and led to the funnel. A throttle valve and drip was provided for this line. A peephole was cut in the side wall and covered with a piece of mica in order to observe the working of the device. In operation the valve was opened, and the steam rushing into the funnel drew in a certain amount of air. This air being heated by the steam issued hot from the perforations and meeting the incoming unburned gases from the furnace would cause innumerable minute explosions, consuming the gas before it reached the rear end of the combustion chamber.

At the time of this demonstration we were burning coke dust and soft coal, 5 to 3. From the start, and during a month's test of the device, we were able to maintain our usual steam pressure with five parts of coke dust to one of soft coal. At that time coke dust cost $1.50 a load and coal $3 a ton. We figured a saving of about $4 a day on that one boiler alone.

Camden, Me. M. M. BROWN.

Gas Engine Repairs

WITH THE resumption of work in a certain industrial plant, I was called in to overhaul and put in service a 90-hp. gas engine which had been overworked


ONE OF THE 4 BOLTS ACTING AS AUXILIARY JAWS & GUIDE
SLOT IN CHUCK
CLAMP
RING
FRONT VIEW OF 4 JAW CHUCK
SIDE VIEW
TURNED DOWN & FILLED WITH WIRE
WORN INTAKE VALVE
ROD INDICATOR
CLAMP MADE OF SQ NUT WAS FASTENED ON RING
TRUING UP PISTON PRIOR TO BORING

SOME SCHEMES USED IN REPAIRING A GAS ENGINE

A. Four-jaw chuck showing auxiliary jaws for holding piston ring true. B. Detail of square nut cut to hold the ring in place. C. Piston set up on the lathe preparatory to boring out the wrist pin bosses. D. Worn intake valve stem was turned down and wound with wire.

during the war. As the repair was somewhat out of the ordinary a description of the job may be of interest.

When the piston, which was 18 in. in diameter, was taken out it was found that the first ring had nearly ⅛ in. play, the second had about 1/16 in. and in the two others the play was slight. This piston was put on the lathe and the two first grooves trued up to 1⅛ in., the two others were not touched for the reason that new rings from the factory fitted well. As there was no stock on hand to make new rings for the large sizes, we had to use old rings, two to a groove. This job, which was none too easy, was done in the following way: Four ⅝-in. bolts were tightened on the four-jaw chuck, using 1-in. nuts under the head to make up to the height of the jaws, then turned down to hold the ring from spreading out between jaws and keep the ring parallel to the cut. A small clamp made of a ⅞-in.

square nut with a 5/16-in. bolt was placed on the ring to act as a lathe dog, to avoid any chance of the ring turning in the chuck. After the rings were turned to the required width, they were hammered. On examination, it was found that the wrist pin had been loose in the piston and had been shimmed with tin and that both holes and pin were worn out of shape. To bore out that hole true was an impossible task with the small drill press available, so the transverse carriage was taken off the lathe and the piston clamped in its place at the proper height. To set up true to the piston, a rod was clamped on the boring bar, one on each side of the piston, to touch both sides. Once set right, the boring with the bar was no trouble. A new pin was made and the repairs to the piston were done. A new piston would have cost around $200 and would have caused a delay of nearly 30 days.

As the exhaust valve was in fairly good shape it was simply put on the lathe and refaced, but the inlet valve was quite worn, at the stem especially. Working horizontally, it seems to have worn from its own weight. The fuel used seems to have a tendency to help to wear. As it is quite a complicated job to put a new stem in an all-steel valve, the following makeshift was resorted to, as a new valve will be ordered for the future. The worn part was turned down 1/16 in., iron wire about 1/16 in. diameter was coiled tight in the turned-down part and well brazed with plenty of brass; when cooled it was turned down to size. This odd job turned out to be quite neat and the valve may be able to give some good service for a while.

CHAS. LABBE.

Boiler Gage Glass Couplings Out of Line

I HAD READ a great deal about boiler gage glasses bursting, but when it came to those in our local boiler room, I had a vague impression that they must have grown there when the boilers were put in, for they had never given any trouble.

We had been doing some work around the boilers on this particular day and everything being finished, boiler No. 2 was cut in on the line with 140 lb. of steam shortly after 6 p.m. At 6:15 p.m. No. 2's 15½ in. of glass parted company with the boiler gage and the boiler was fired until 11 p.m. by using the try cocks. Next day we put in a new glass, only to have the same thing happen the following night. Yet another night, and the same occurrence.

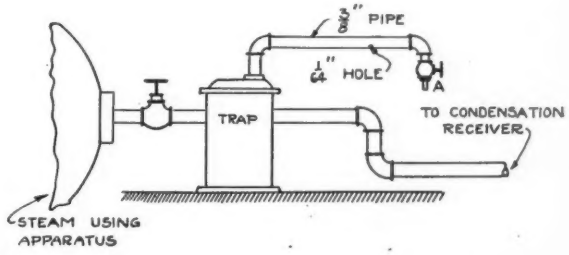
I then went to the machine supply house where we were buying glasses and asked if they had any glasses of the unbreakable kind. The clerk replied that he had not, but that the kind of glass he had been furnishing us was one of the best imported glasses on the market. I was in a quandary as to what to do, for evidently the same thing would happen again. Just then an old engineer friend happened along and hearing the noise, said: "Say, Joe, have you looked to see whether the couplings that hold the glass are in line?"

A light dawned. I got two more glasses and went back to the plant. On squaring up the couplings, it was found found that they were slightly out of line, evidently having been jarred out the day we worked on the boilers and had the first trouble. We trued them up and put in a new glass and since then the spare has been on the shelf.

Fredericksburg, Va. J. B. FICKLEN.

Air Vent Prevents Binding

I HAVE a steam using apparatus in my plant used for drying purposes. This apparatus must always be clear of condensation to do good work. The steam trap in use is of the bucket type. This trap had a way of getting air bound quite often during the day, hence it would not work until this air was removed by opening the pet cock as shown in the illustration. It kept me or some one else busy opening the pet cock quite a number of times during the day to leave the air out, otherwise the trap would not close and the steam would blow by or the trap would not open and there would be complaints that the apparatus was not hot.



LOCATION OF VENT WHICH KEEPS STEAM TRAP FROM AIR BINDING.

After drilling a 1/64-in., or smaller, hole into the ⅜-in. pipe between the pet cock and trap, as shown, there was no further trouble with the trap getting air bound during the day. All that is necessary is to discharge from the trap all air when the steam is turned into the apparatus, by leaving the pet cock wide open until all air has escaped, then the pet is closed for the rest of the day's run, and the hole in the pipe does the rest. Of course, leaving the pet cock partly open would have answered the same purpose; but in leaving a pet cock partly open it will be cut by the steam so that in the course of time it will leak badly. The reason the pet cock is located such a long distance from the trap is because the trap is located in such position that it is hard to get at.

H. A. JAHNKE.

Be Careful of Ammonia Saturated Oil

IN THE Jan. 15 issue of Power Plant Engineering, on page 144, there is a question by R. G. S. concerning ammonia trapped in an expansion pipe which calls to my mind an incident to which it might be worth while to call the attention of your readers.

Not long ago, we took on a new man in our refrigeration plant. He was unaquainted with the work and was warned to play safe and keep out of harm's way. One of his jobs was to drain the oil out of the expansion coils after they had been pumped out. To do this, he had to disconnect the expansion coil at the bottom of the cooler, since it had no drain. The pipe flange stuck on the gasket, so he lay down on his back with his head under the pipe and worked the flange loose.

Naturally, the oil came in a stream and splattered on his face, just missing his eyes. He was being overcome by the fumes when he was seen and pulled out of the way. Long after this experience, he had blisters on his face caused by the ammonia absorbed by the oil. oil.

All oil that has been in contact with ammonia will contain some of the gas, so be careful how you handle it.

Brooklyn, N. Y. E. MATZAN.

Leveling with a Hose Full of Water

COMMENTING on the letter by Chas. Labbe on the question of leveling with a hose full of water, I would say that one man can handle the hose full of water by having one end fastened at the terminal of the shafting or at any other desired point. He can then move

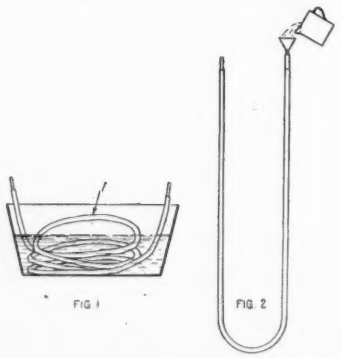


FIG. 1. BUBBLES OF AIR WILL ACCUMULATE IN ANY SECTION OF THE HOSE WHERE THERE IS A CONCAVITY DOWNWARD
FIG. 2. ALL AIR BUBBLES MAY BE ELIMINATED BY FILLING THE HOSE IN THIS POSITION

around freely with the other end to any position along the shafting that is to be leveled with the fixed end.

Regarding the exclusion of air by immersing the hose in a tub of water, that method will not necessarily exclude all of the air, especially if the hose is coiled, and for the reason as shown in Fig. 1. This is true because if a portion of a coil, A, is convex upwards, as sketched, no matter how carefully the hose is immersed, air is liable to be trapped in this portion of the hose, or in any portion that is convex upwards.

To exclude air, the surest way is to allow the hose to assume the form of a U as sketched in Fig. 2 and then pour the water into one leg of the U as indicated. Boiled water is better for this purpose than unboiled water, because on boiling, dissolved air is driven off. Then to be still further certain of the exclusion of the air, allow the water to remain in the hose over night so that all little air bubbles will find their way to the surface. Also, be certain that the temperature of the water in both legs is the same; if the temperature of the water in one leg is higher than in the other, its level will naturally be higher due to its lesser density.

There is no question but that when this method is properly executed the level in the glasses at both ends will prove to be reliable for leveling shafting, foundations, girders, or anything else in or about the power plant.

W. F. SCHAPHORST.
Newark, N. J.

A Gasket Impervious to Steam

IN READING the article by Chas. N. Shaw on page 142 of the Jan. 15 issue, "Regarding the Master Mechanic," I was reminded of a similar incident where the engineer in charge was unable to start his engine. One Monday morning, one of the men who had charge of some boilers and engines in the plant where I was working at the time, came running into my boiler room, much perturbed. "Say!" he said, " come over right away; there is something wrong with the engine; she won't move."

There was no time to chew the rag with him, so I went over to his engine room. I tried the throttle valve and found no steam there so I asked him if the stop valve was open. He replied that it was, so I went down in the basement where the steam line was located. This line was drained by a trap at a point just ahead of the throttle. Trying the bypass around the trap, I found plenty of steam. On looking up at the flange of the valve, I found that the bolts had recently been taken out. When I called his attention to this he said that he had put in a new gasket Sunday. The difficulty was plain then, so I told him that he had made a good job of it except that he should have cut a hole in the gasket.

It might possibly have blown out after a while, but he had only 60 lb. pressure on a 4-in. line and the gasket was wire inserted rubber, so it held in good shape. We took the joint apart and cut a hole in the center and you should have heard his comments while this was going on, but they won't bear repetition.

Now this man was an old hand at the business and knew better, but it just goes to show how easy it is to make a mistake. The point is, of course, to keep your mind on what you are doing.

Newburgh, N. Y. GEORGE S. VELIE.

A Man's Title Does Not Describe His Ability

I READ WITH some interest the articles in the Nov. 1 and Dec. 15 issues concerning the relationship of the chief engineer to the master mechanic. The trouble, as I see it, is a personal one in each case. It all depends on the individual concerned. In this respect, I would like to mention some experiences I have had.

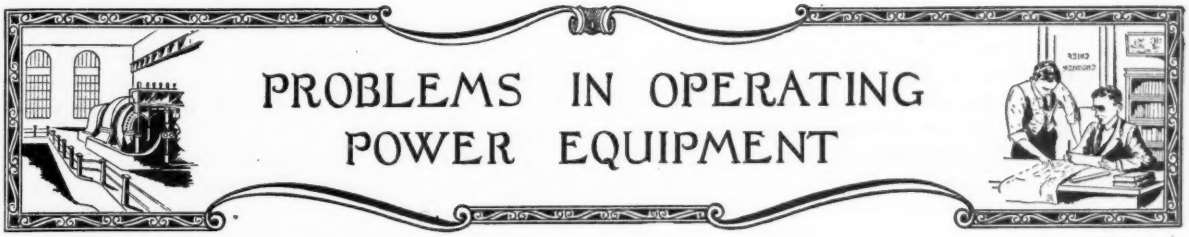
Now, these two men mentioned were both supposed to be engineers and went with that title; but they were, nevertheless, not engineers in the true sense of the word. It is not the man's title that accounts for his actions, but rather the man himself. There are good master mechanics as well as poor ones, just as there are good and poor chief engineers, or doctors, or lawyers, or anything else.

Coeur d'Alene, Ida. L. E. H.

Cure for a Balky Tank Valve

IN OUR plant there is a float valve controlling the flow of water to a barrel from which the feed water injector takes its supply that has been giving trouble. When I purchased and installed this valve, it was fitted with a hard filter disc, which, in a short time, refused to close tightly. From the beginning it made a whistling noise that could be heard all over the plant. I was able to cure the trouble by substituting a soft rubber disc of the same thickness. The valve is now quiet and perfectly tight.

R. G. SUMMERS.



Piston Ring Size

WE HAVE a 28 by 36-in. engine using steam at 120 lb. pressure that is at present under repair. We are going to put new rings on the piston and would like to know how much larger than the cylinder the rings should be made. What should be the thickness of the ring at the joint and also at the back? The grooves in the piston are 1 in. wide. The engine manufacturers sent us rings 2 in. larger than the cylinder and instructed us to cut them to the right length and then peen them to fit. They are the ordinary cast ring similar to those used in small cylinders. I. W. C.

Centrifugal Tension in Belting

WITH FURTHER reference to the discussion on centrifugal tension in belting in Power Plant Engineering in which the writer took part, the following may be of added interest. These have come to mind as occurrences in the writer's experience. I now believe that the centrifugal effect was the cause of the behavior of these belts.

We found that in a vertical drive somewhat like Fig. 1, an idler pulley was necessary. The belt was sufficiently long so that we had considerable wrap around the lower pulley. We found after getting started and after operating at full speed, that the idler could be entirely removed to the position indicated by the dotted line and the drive would keep right on running as if the idler pulley were in place.

I used to run a machine shop that was driven by a high-speed steam engine and we used a heavy leather link belt which was extremely slack. When the engine was not running, the belt would hang in a position indicated by the dotted lines, and we could not start the shop without bearing down on the top side so as to force contact between the belt and the pulley of the steam engine, Fig. 2. By forcing this contact, the belt would assume its proper position and after acquiring a speed sufficiently high, the belt would stay in place without holding.

In each instance I believe that the centrifugal force acting on the concave side had nearly everything to do with holding the belt in position.

An investigator comparing wood pulleys with cast-iron pulleys shows that centrifugal effect is noticeable more quickly on cast-iron pulleys than on wood pulleys. He writes as follows:

"If iron pulleys be operated at speeds to give, say, 2000 and 4500 ft. per min. belt speed, and loaded to cause, say, one per cent slip, the 3-in. belt on 24-in. pulleys will develop at 2000 ft. per min. a turning effort on the driven shaft of 106 lb. at 1 ft. radius, while at 4500 ft. per min. it will develop only 77 ft.-lb. If wood-split pulleys be used, they will develop at the same slip, one per cent, 138 ft.-lb. torque, whether operated at 2000 or 4500 ft. per min. This must mean that the cling of a belt to a wood-split pulley is not altered by change in centrifugal force on the belt between 2000 and 4500 ft. per min. on 24-in. pulleys, whereas the cling to the iron pulley is reduced in the ratio 106 to 77, or 27 per cent, under the same conditions."

Newark, N. J. W. F. SCHAPHORST.

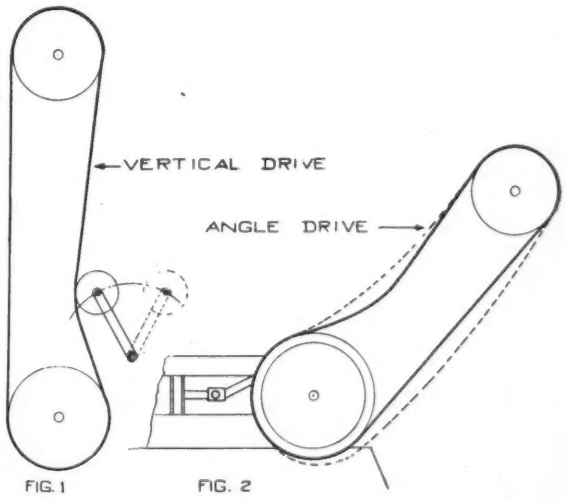


FIG. 1. AT NORMAL SPEED, THE BELT ON THIS VERTICAL DRIVE HUGS THE LOWER PULLEY EVEN WHEN THE IDLER IS NOT USED

FIG. 2. TO START THE DRIVEN PULLEY, WHICH IS ALWAYS UNDER LOAD, IT IS NECESSARY TO FORCE BELT CONTACT AT THE DRIVING PULLEY

Some Comments

ON PAGE 147 of the Jan. 15 issue, S. T. J. presents some first class engineers' questions and answers. Question No. 3 asks "What is the split baffle that is used on large Heinie boilers?" and the answer given is that the middle baffle is the split one, that it is made of cast iron, and is placed on the tubes when the boiler is erected; to get it out, a hook is used for pulling the baffles up through the tubes. My comment is that on a boiler of this type, the middle baffle is composed of what is known as "B" tile, made of fire brick. They are put in through the stay tubes in the water legs.

Question 4 asks if it is possible to get compression so high in a cylinder that the safe working pressure will be exceeded. The answer refers only to a slide valve. If he had a piston valve, what would happen? There

would be no chance for it to lift, therefore the compression might be excessive.

There are more kinds of balanced valves than the one mentioned in Question 5, for instance the piston, the Skinner, and the telescopic valves. The clearance of 0.005 in. mentioned for pressure plate valves is somewhat large and is liable to cause leakage. A clearance of 0.003 would be better.

On page 145 C. J. Mason, in comment on the elimination of oil from exhaust steam, says that the trouble is due to the use of compounded oil. How can this be remedied? Is it not necessary that compounded oils must be used where the steam pressure is low or where there is so much condensation that a straight mineral oil would wash off?

"How would you know when a safety valve is too large for a boiler?" is a question asked by P. O. M. on page 144. In Massachusetts no valve can be used that is over 5 in. in diameter, and there are tables available from which the proper size can be determined and from this an engineer can tell pretty well whether his valve is too large or not. An average valve, if it is under 5 in., is not likely to be dangerous. The danger, if any, would be the tendency of the water to flash into steam so rapidly as to cause it to rise off the bottom of the shell, and in dropping back on the hot shell would cause an over pressure at that point.

Springfield, Mass. F. C. E.

Application of Superheated Steam for Heating

In the Nov. 1 issue of Power Plant Engineering, F. W. Bosch, in his article on "Commercial Value of Exhaust Steam," discusses the merits of superheating exhaust steam.

What is the best method of accomplishing this superheating? Is there any standard equipment on the market?

In our plant, large amounts of exhaust are available, but are used for feed heating only, although our process requires approximately 30,000 lb. of steam per hr. for heating and cooking purposes. We do not care to use exhaust at 212 for heating and cooking in our coil-equipped or steam jacketed kettles, as this would require more heating surface than we have available, and at the same time slow up the process too much.

Temperatures carried in the steam jackets are around 320 deg. F. Now, suppose we used superheated exhaust; to what temperature would we have to superheat it to get the same results in the same time, considering that superheated steam does not release its heat content as readily as does saturated steam? B. P. P.

A. There is no difficulty in the design and use of superheaters for this purpose, in fact, superheating the steam is probably the easiest part of the problem. The difficulties lie in the use of the superheated low pressure steam. In the first place, the rate of heat transfer per square foot of heating surface is enormously greater with saturated than with superheated steam. In fact it is one of the great advantages of superheating that loss of heat to the cylinder walls of reciprocating steam engines is greatly reduced because of the much smaller rate of heat transfer from the superheated, and consequently dry steam, to the metallic surfaces. Even where the steam comes in direct contact with water, the transfer of heat is much slower with superheated than with saturated steam, and for this reason injectors to be operated with superheated steam have to be provided with much longer mixing cones than is the case with those using saturated steam.

The trouble is further aggravated by the much smaller amount of available heat for any given temperature drop. Taking the example or data given where a temperature in the jackets of 320 deg. is required. This is secured with saturated steam of 90 lb. absolute pressure. Condensing this steam in the jackets provides 896 B.t.u. per lb. of steam, assuming the condensed water to be drained off at the temperature and pressure of the steam. Now take steam at 5 lb. pressure (say 20 lb. absolute) and superheat it say to 400 deg. to supply the jackets and let it leave the jackets at 300 deg. so as to give a temperature drop of the steam of 100 deg. (In some processes, the limits of temperatures of the steam in the jackets will be much closer than this to avoid damage to the product). The total heat in the entering steam is 1240.2 and in the reject 1192.7 B.t.u., leaving a difference of 47.5 B.t.u. per lb. of steam. The B.t.u. given up per lb. of saturated steam was 896, so that nearly 20 times the weight of superheated steam would be required.

This, of course, is only another way of saying that the specific heat of superheated steam is a much smaller quantity as regards practical applications than is the latent heat of saturated steam; however, while it is generally accepted that superheated steam does not give up its heat as readily as saturated steam, this is true only to a certain extent. Saturated steam is usually admitted to the radiators and stays there until it is condensed, the condensate then being removed through traps. If moderate superheated steam is used in the same radiators in the same way, it will not condense until it loses all the heat of superheat, which heat is not so readily given up as the latent heat of saturated steam. Less heat will, therefore, be transmitted, and the process may be slower.

If, however, the temperature of the superheat is considerably higher, and the steam flows through the radiators with a considerable velocity, then the heat transmission is appreciably increased. The velocity and the temperature of the steam can be so chosen that the temperature of the radiators, or steam jackets, is higher than that of saturated steam, in which case considerably more heat is radiated or transmitted than with saturated steam.

Whether this arrangement could be applied advantageously in your specific case could be determined only if more data is furnished regarding the purpose for which the steam is used, accompanied by a sketch showing the apparatus. Information regarding the maximum temperature possible, the amount of steam available, and other data in this connection would help to solve the problem in a definite manner.

Camden, N. J. Fred William Bosch.

Ammonia in Open Pipe

Ammonia gas leaving the split in a pipe-bend as mentioned by R. G. S. in the Jan. 15 issue was probably due to ammonia absorbed by the oily coating on the inner surface of the pipe.

Some of the ammonia oil used in the compressor will always pass through the oil trap to the condenser and from there follow the liquid through the system; on its way it will coat all surfaces with which it comes in contact.

When any part of the system is pumped out, this oily coating will still hold ammonia, which will evaporate but slowly if the surrounding air is cool.

Vapors coming from the pipe in question were not strong enough to be noticed before the pipe was being bent. Since the seam of the pipe opened, I take it that the job was attempted on the cold pipe. Due to the bending stress in the iron, a slight heat was developed and this heat liberated the gas from the oil, which followed the shortest way out; that is, through the opened seam.

No ammonia system was ever proof against oil being carried around with the ammonia; that is why such a system should be pumped out, opened up and cleaned occasionally. It is always well to remember that even when the system is pumped out thoroughly there is still ammonia held in the oil. When the cleaning out is done once every year, the writer would drain about 25 bucketfuls of oil from an upright cylindrical 50-T. brine-cooler.

Brooklyn, N. Y. E. MATZAN.

Charcoal as an Insulator

WE HAVE been having a discussion of the relative advantages and disadvantages of charcoal as an insulating material for refrigeration work, and would like your opinion as to how it is used and what efficiency it gives.

R. G. S.

A. Charcoal and other similar materials should not be used for insulating purposes because of the fact that when it is exposed to the action of the atmosphere and allowed to stand without turning for any length of time it is subject to spontanenous combustion and constitutes, therefore, a dangerous fire hazard. Its use is not generally recommended, nor is it even allowed by most insurance underwriters. Usual specifications require that where charcoal is stored it should be kept in airtight containers.

Charcoal has, however, been used for insulating purposes and when so used is invariably in a pulverized or powdered condition. In this form the co-efficient of heat conductivity is about 1.3 B.t.u. per ft. of thickness, per sq. ft. of surface, per deg. difference in temperature per hr. It thus compares favorably with sawdust or cotton wool. When packed solidly, as it should be, it has a density of about 11 lb. per cu. ft.

Surface Required for an Evaporator

WILL YOU kindly tell me how to figure out the amount of pipe surface required to evaporate one pound of water per min. at atmospheric pressure from a feed temperature of 60 deg., with steam at 5 lb. gage pressure?

W. G. L.

A. There are so many factors that affect the result that a number of assumptions will have to be made and, of course, the correctness of the result will depend upon the correctness of the assumption, which, in turn, depends somewhat on the experience of the designer. The coil surface required depends upon two things, the coefficient of heat transmission through the coil from steam to water, and upon the mean temperature difference. The coefficient of heat transmission depends upon the rate of movement of both the water and steam, the material of which the coil is made, and the amount of scale formation on the water side. In practice it is found that this coefficient of heat transmission varies within rather wide limits; but we may assume for want of better data that where there is no forced circulation of the water or any through circulation of steam, this coefficient for moderately clean surfaces may be taken at say 150 B.t.u. per sq. ft. per deg. difference in temperature per hr. The temperature of the water being boiled under atmospheric pressure is 212 deg. F. and the average temperature of the steam is $(228 + 212) \div 2 = 220$ deg. F., where 228 is the temperature of steam at 5 lb. gage pressure. The temperature difference is then $220 - 212 = 8$ deg. F. To evaporate 1 lb. of water per min. from a temperature of 60 deg. will require $970.4 + 212 - 60 = 1122.4$ B.t.u. per min., or 67,344 B.t.u. per hr. The heat transmission is $150 \times 8 = 1200$ B.t.u. per sq. ft. per hr., so that the surface required will be $67{,}344 \div 1200 = 56$ sq. ft.

How Much Pipe Surface Will Be Required?

I SHOULD like to know how to compute the following problem. A drying room, used for drying clothes, has 1120 ft. of 1¼-in. pipe coils and the steam pressure carried is 100 lb. gage. How much additional surface would be required to accomplish the same result, using steam at say 2 lb. gage instead of 100 lb.? I do not know the exact temperature of this room but I should judge it to be around 175 deg. F. S. P. E. C.

A. As the quantity of heat transmitted through steam coils to a room is directly proportional to the temperature difference existing between the steam and the room, if your reduce the temperature of the steam and at the same time maintain the same temperature in the room, it would be necessary to provide more surface by an amount in an inverse ratio to the amount that the temperature is reduced. The temperature of steam at 100 lb. gage is 338 deg. F. and as your room temperature is 175 deg., the temperature difference 163 deg. As the steam pressure is reduced to 2 lb. or, say, 17 lb. absolute, the temperature is reduced to 219 deg. and the temperature difference in this case is only 44 deg.

To supply the same amount of heat at this reduced pressure and temperature would require

$$163 \div 44 \times 1120 = 4150 \text{ ft. of } 1\tfrac{1}{4}\text{-in. pipe.}$$

There is, however, another factor that should be given consideration and that is the question of steam velocity in the system. The specific volume of steam at 17 lb. pressure is about 6.2 times that at 115 lb. and while less steam will be required in the ratio of the heat of evaporation at the two pressures, i. e., $880 \div 967$ or about 0.91, the volume handled will be $6.2 \times 0.91 = 5.6$ times as great. Necessarily the velocity will be 5.6 times as great if the pipe size is the same. The thing to do then is to provide a larger header and arrange for more of the coils to be supplied in parallel.

POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

Published by the Technical Publishing Co.
537 South Dearborn Street, Chicago.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Issued the 1st and 15th of each month. Established over 28 yr.

Subscription price $2.00 a year in the United States and all its possessions. Canada $2.75 a year. All foreign countries $3.50 a year.

Copies of current issue, 15 cents; of back issues, 25 cents.

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Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

New York Office, 150 Nassau St.

Circulation of this issue, 21,000.

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De Luxe Service Requirements

There are few classes of service for which the power requirements are more rigid than that encountered in hotel or office building operation. Particularly in the case of the former, the service is so diversified as to require the satisfying of almost every need for human comfort. Not only is power required for heating and lighting, but also for cooking, cleaning, refrigerating, ventilating, etc., and it is absolutely essential that this service be maintained 24 hr. a day, 7 days a week.

It is obvious, therefore, that a power plant for this class of service must have embodied in it all possible features which make for efficiency, continuity, and flexibility of operation. At the same time, such a plant in order to be in keeping with the institution it serves must possess an attractive appearance and be free from noise.

Office building and hotel power plants are, as a rule, located in more or less out of the way places, usually in the basement or sub-basement of the building. This fact naturally places certain limitations on the design of the plant insofar as appearance and accessibility of equipment is concerned, and in certain cases expensive forms of foundation construction have to be resorted to, to reduce the effects of noise and vibration to a minimum.

Housing the power plant in a separate building apart from the office building or hotel proper is obviously the most advantageous arrangement, but this usually requires an additional investment of capital which is prohibitive. Furthermore, office buildings and hotels are usually located in business sections of towns and cities where, due to space limitations, such an arrangement would be out of the question.

There are exceptions to every rule, however, and in the pages of the current issue will be found a description of an office building plant in which the idea of a separate power plant has been fully carried out.

In this particular case, the location of the project was such that it was possible to secure a plot of ground some distance away from the building and adjacent to the railroad upon which to build the power plant. This power plant is connected to the main building by a large tunnel through which all water, steam and electricity is carried.

The General Motors Building is the largest office building of its kind in the world and its service requirements are even more diversified than that of the average modern hotel. With its hundreds of rooms, its spacious sales rooms, its restaurant facilities, its swimming pool, its hotel accommodations, its refrigerating plant, not to mention the large research laboratories which alone call for many different types of service, this building demands a degree of service that cannot be approached anywhere else. De luxe service expresses it in a nut shell.

Mr. Wilcox, the author of the article describing this plant, because of his former connection with the General Motors Corporation as superintendent of power of the building, knows the mechanical details of this wonderful institution better than any other single individual. He contributed much to its design and is largely responsible for its high degree of mechanical perfection. His thorough description of the power plant and the mechanical features of the building should be of interest to all connected with the engineering profession.

How's Your Turbine?

So simple does a turbine seem and so steadily does it perform that there is a tendency to feel that it is self-adjusting and needs no care or inspection. It is, however, a high speed machine, and to insure satisfactory condition and running at all times, must be kept in the best of condition, but the routine needed is not so commonly understood as that for reciprocating units.

Mr. Willison, in this issue, begins a series of articles giving in detail just how the engineer may establish a routine which will make reasonably certain that there will be no mishaps or interruptions to service. Evidently, as large weights are being operated at high speed, lubrication is of vital importance. What precautions should be taken in regard to the oiling system and bearings? This is one of the questions answered by Mr. Willison.

Leakage of steam is always a loss of efficiency, and is usually caused by bad handling of the packing problem. Carbon packing calls for different treatment from either fibrous or metallic packings. How to care for all three is another question to which the answer must be known.

Smooth running requires good alinement; but experience has shown that a turbine casing expands under steam, so that lining up cold may not produce good alinement when running. How can this be met? Again Mr. Willison gives the answer.

To handle a modern plant, knowledge of the routine care of turbines is indispensable, for use of turbines for some purpose is almost universal. Readers cannot afford to overlook the series of articles which Mr. Willison has prepared for their aid.

Operation of Electrical Equipment

Nothing is more important in the successful operation of power plant equipment than a thorough knowledge of the fundamental principles upon which such equipment operates. This, of course, applies to all kinds and types of equipment, but is especially true of electrical apparatus.

In the case of a pump, or a steam engine, or an air compressor, the man with the mechanical type of mind will usually have no difficulty in picturing to himself, exactly what goes on in the machine. Water, steam and air are material entities, the action of which can be visualized when they are subjected to certain conditions. With electrical apparatus, however, a different condition exists. To the average man not versed in the deeper theories of modern electrical engineering and physics, electricity is still the intangible nothingness, which we cannot see, or feel, but of which we only know its effects. Closely associated with electricity is another equally mysterious thing, of which we know even less than electricity itself, that is magnetism, and when, as in all electrical apparatus, magnetic phenomena is inter-related with electrical phenomena, the non-electrical man in attempting to visualize the action of an electrical device, becomes lost in a maze of intangible conceptions.

And, yet, to those familiar with the fundamental principles of electrical engineering, the visualizing of the action of electrical apparatus is not difficult. When we begin to understand the meaning of magnetic fields and of dielectric stress, it becomes a relatively simple matter to visualize what is going on in an electric circuit. A thorough knowledge of the underlying principles involved is the key to the entire situation. The electrical engineer, by virtue of his specialized training, thinks of the electric circuit much as the mechanical engineer thinks of a system of piping in a power plant, and has no more difficulty in visualizing the action of the electric current in the circuit than the mechanical engineer has in visualizing the passage of water or steam through the system.

In an article dealing with the operation of electrical equipment it is necessary to include a discussion of the fundamental principles upon which the apparatus operates. In the series of articles on the Operation of Electrical Equipment by V. E. Johnson, the first of which appears in the current issue, the author has taken particular care to present the fundamentals in a clear and simple manner. While, it is true, he does not discuss the electron theory of matter, he does take up the more practical considerations involved in electrical theory, and from this point of view his articles should appeal to the practical engineer, for whom they are intended.

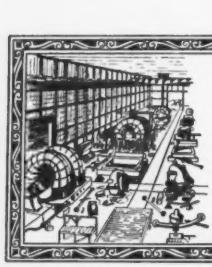
Scale Prevention

As is generally recognized by power plant engineers, scale is one of the most prolific causes of inefficiency in any apparatus transferring heat to water; particularly is this true in the case of boilers. To alleviate this condition various methods are employed; tube surfaces may be cleaned by mechanical tube cleaners, boiler compounds which change the nature of the precipitated material may be added to the water in the boiler, or the water may be chemically treated before it enters the boiler. The ideal condition, however, as far as theory is concerned, is to feed chemically pure water to the boiler; that is, water having neither dissolved solids to cause scale formation, nor dissolved gases to cause corrosion. Such boiler feed may be had by the use of evaporators and condensers. This latter method, while it has been used extensively in marine service, has been considered rather costly for small land plants.

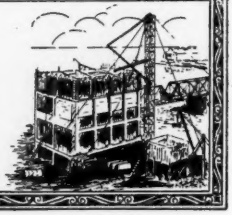
By using distilled water for boiler feed make up, however, it is possible to operate the boilers at a much higher rating than would otherwise be possible. This means, of course, that to meet a given steam demand fewer units will be required, which, of course, represents a smaller initial investment and consequently reduced fixed charges. This overrating, however, must be maintained if the added investment in an evaporating system is to carry itself.

Another prerequisite for the successful use of evaporators is that the amount of make-up water required be comparatively small. This, then, calls for surface condensing equipment or a heating system where all exhaust is condensed and returned to the boiler as feed water. It can not be said that feed water evaporators are applicable to all classes of plants; but where conditions are favorable, they may be made to show a considerable saving in the cost of operation.

That this is so is shown in an article on low pressure evaporators by John Forbes, which appears elsewhere in this issue. Figures are given which indicate that equipment for a plant of 2000 boiler hp., operated at 150 per cent of rating and requiring but 5 per cent make-up water, will pay for itself in 2 yr.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Induction Motor Has One-Piece Winding

IN THE new L A, Type H D induction motor which has recently been placed on the market by the Louis Allis Co., of Milwaukee, Wis., it is interesting to note that in one respect, at least, a really new and original development has been made in the method of rotor construction.

As may be seen by reference to the accompanying illustrations, the entire winding of the rotor consists

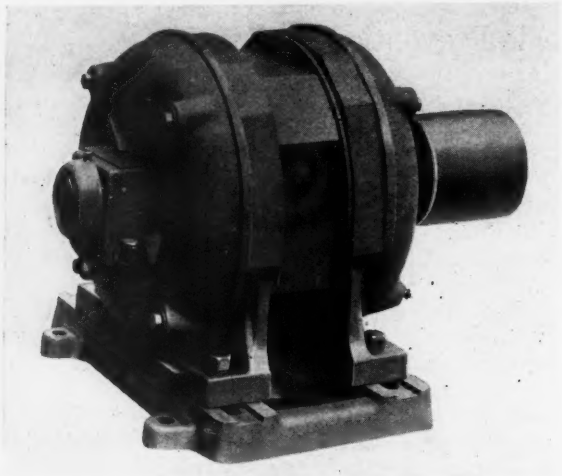


FIG. 1. LOUIS ALLIS, TYPE H D INDUCTION MOTOR

of an integral sheet of copper, punched and formed by a special mechanical process. This one-piece winding is machine wrapped around the rotor core, and the copper bars expanded into the core slots by swaging. The single joint which extends through the two end rings is silver welded, after which the metal at both connections is processed by means of a contracting operation that rehardens the copper at the point where the heat, applied during the welding, softened it.

This treatment results in a lapped, silver welded joint of maximum strength. The rotor-winding, except for the joint in the two end rings, is electrically and mechanically just as substantial as a piece of pure copper pipe.

On account of being fabricated of comparatively thin copper stock, which material has a higher thermal conductivity, this rotor winding readily conducts the heat generated in it toward the ends of the rotor bars where this heat is dissipated through the action of the malleable iron jaws. The rotor bars themselves also constitute a blower, thus materially increasing the ventilation.

These motors are designed to meet the severe demands of modern industrial service and to carry their full rated load continuously with a temperature rise

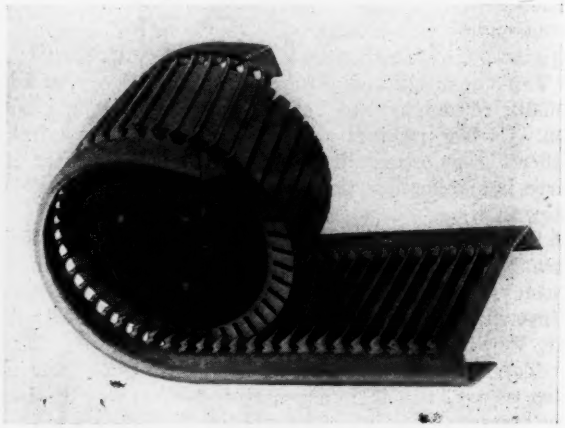


FIG. 2. SHOWING METHOD OF WRAPPING ONE PIECE WINDING AROUND CORE

not exceeding 40 deg. C. and after their ultimate temperature has been reached, to carry 25 per cent overload for two hours with a temperature rise not exceeding 55 deg. C.

Southern Pacific May Use Geyser Power to Run Trains

EXPERIMENTS which are said to be backed by the Southern Pacific Railroad, leading toward the utilization of steam from wells in the Sonoma county geyser

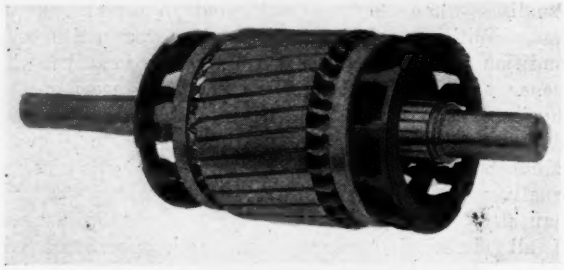


FIG. 3. THE ROTOR, COMPLETE

country of California, have recently been carried out. A test well has developed a flow of steam at 68 lb pressure, 327 deg. F., sufficient for the development of 2000 hp. if properly utilized. From a survey of the possibilities it would appear that power from this source alone could be used to drive all the trains within a radius of 500 miles of San Francisco.

It is said that a company now being formed to promote this power development, has acquired a stretch of land 10 mi. long in the geyser district and that the sinking of 1000 of these wells is not beyond the realms of possibility.

This idea is by no means new, as hot springs have been used in Italy for the production of power and it would appear to be practicable in the Sonoma geyser regions. At least a number of hard-headed men of industry are giving the subject serious consideration.

Unit Type Air Filter

AN INGENIOUS type of air filter which utilizes a unique principle of air filtration is being manufactured by the Midwest Steel & Supply Co., New York. Air cleaning equipment similar in design and embodying the same principle of air filtration has been in use in Europe for several years.

One or more filter units of a given capacity compose a filter installation. A unit consists of a frame and a cell. Each frame is the support for one cell. Any capacity filter can be obtained by bolting together two or more frames, to which a cell can be attached. The over-all dimension of a unit is 20 by 20 by 20 in. There are holes in all four sides of the frame, making it possible to bolt together the desired number of units in any arrangement.

Due to this equipment being supplied in units, it is highly flexible. The units can be bolted together in any shape or design so as to conform to local conditions and economize in space. Only the number of units necessary for the quantity of air desired need be secured. The capacity of any existing installation can easily be increased by adding additional units, involving in many instances only the cost of the necessary number of units. The interchangeability of the cells with all the frames enables the continuity of service to be maintained, as a spare cell can be placed on any frame where a cell has been removed for cleaning. The cell proper which holds the filter bodies is shown in Fig. 1. It is 3¼ in. thick and has an expanded metal front and a perforated sheet metal back. Near each corner of the cell proper there is a slotted opening which permits the cell to fit over lugs on the frame.

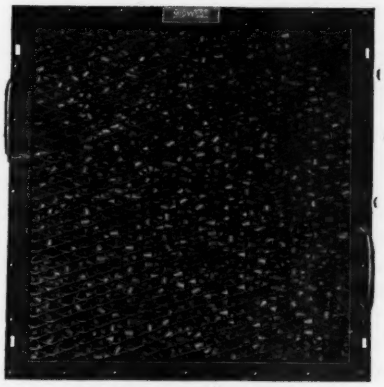


FIG. 1. UNIT FILTER CELL SHOWING THE SMALL CYLINDERS USED TO BREAK UP THE AIR FLOW

When in service the filter cell is completely filled with small metal cylinders or ferrules which cause the air, when it is forced or drawn through the filter bodies, to change direction many times, and it is this changing of direction of the small air streams which causes the dust and dirt particles to inpinge against the inside and outside wall of the small cylinders which are covered with a film of liquid called Viscosine, which holds any dust or dirt particles which come in contact with it.

In the ordinary size installation, such as shown in Fig. 2, for instance, only one cell is removed at a time and this is immediately replaced by reserved cell which has previously been cleaned and recharged. At a set interval another cell is removed and likewise replaced by a clean cell. All the cells are thus replaced in turn, so that the entire filter is completely overhauled in a certain predetermined period.

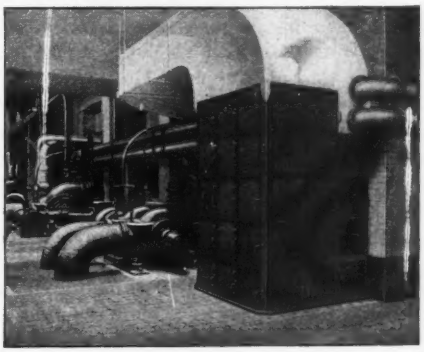


FIG. 2. AIR FILTER INSTALLATION FOR A SMALL SIZE TURBO-GENERATOR PLANT

Dirty cells are washed in medium hot water containing a little soda and after they are allowed to dry they are recharged by immersing in the Viscosine. When the surplus fluid is drained off, the filter is ready for service. The frequency of cleaning depends, of course, on the quantity of dust in the air.

These filters may be used to clean the air for various purposes such as for turbo generators, air blast transformers, mill motors, also to clean the ventilating air used in buildings. The same principle of air filtration may be utilized in filters to clean the air taken in by air compressors.

New Water Power Development Planned for Maine

PLANS for the development of a power project through co-operation of power companies and large industries located on the Kennebec River in Maine are progressing rapidly and it is expected that by early spring actual construction work will commence. Options have already been secured on the property required.

Two plans are being developed, either one or both of which will probably be carried through to completion. One calls for the establishment of a large basin along the Dead River in the Flagstaff district. The other plan calls for establishing a similar basin contiguous to Brassau Lake in the Moosehead region. It is probable that the former project will be the one upon which work will first commence, although the options secured include both projects.

Construction of either one of the proposed dams would involve a large expenditure and it is probable that before the actual construction work begins, a separate corporation will be organized with sufficient capital to carry out the project, backed by the companies interested. Whether any of the financing will be done outside the companies interested has not yet been determined.

Companies which have already agreed to participate in the development of the water resources of the river are the Lockwood Mills of Waterville, Me., Central Maine Power Co. of Augusta, Me.; Hollingsworth & Whitney Co., Winslow, Me., and Madison, Me.; Edwards Manufacturing Co., of Augusta, Me.; Shawmut Manufacturing Co. at Fairfield, Me.; Great Northern Paper Co. at Madison, Me., and International Paper Co. at Solon, Me. It is expected that a number of other large industries will be included in the plan before actual work starts.

In addition to furnishing power for the companies interested, it is proposed to establish transmission lines and supply current at a low cost to many communities along the river as well as to extend the lines through rural communities and provide them with light and power.

Many of the industrial plants along the river have annually suffered loss because of the uneven flow of water, which provides a large part of the power at present used. By establishing a huge reservoir as indicated and by construction of a power plant at this dam or at the two dams, it is believed that not only will a regular and permanent source of power be established but that current can be manufactured in one large plant far more economically than by having each industry manufacture its own power.

Tests of Large Powdered Coal Fired Boilers

PRELIMINARY STATEMENTS presenting some of the results of boiler efficiency tests carried out at the Lakeside Station of the Milwaukee Electric Railway and Light Co. by John Blizard, of the U. S. Bureau of Mines, and Henry Kreisinger, research engineer of the Combustion Engineering Corp., show some remarkable results. The boiler tested was equipped with specially designed furnace and burners for burning powdered coal, it has 13,380 sq. ft. of heating surface, and is one of eight boilers equipped with the Lopulco powdered coal system supplying steam to two 20,000-kw. turbines. Twenty-six tests were run at rates of heat transference varying from 4000 to 8000 B.t.u. per sq. ft. of heating surface. The mean thermal efficiency attained was about 84 per cent, based on the gross heating value of the fuel as fired. The efficiency varied but little with the rate of steaming and its high value is accounted for by the small loss from incomplete combustion and also the small amount of excess air which varied from 5 to 36 per cent.

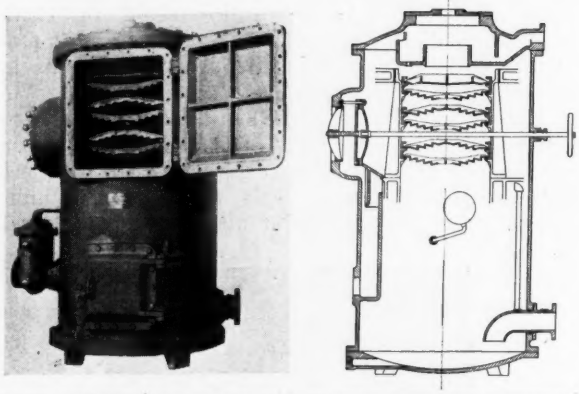
Coal burned had a gross heating value of from 11,500 to 12,800 B.t.u. per lb., contained 2 to 5 per cent moisture, 33 to 36 per cent volatile matter and 9 to 13 per cent ash. It was ground so that 89 to 95 per cent would pass a 100-mesh screen.

The highest rating attained was 257 per cent at which the boiler and superheater efficiency was 82.1 per cent; the lowest was 130 per cent with an efficiency of 84.5 per cent. The highest boiler and superheater efficiency attained, based on gross heating value of the coal was 86.9 per cent and the lowest 79.5 per cent. The highest efficiency including the economizer was 91.3 per cent. Based on the net heating value of the coal, the boiler and superheater efficiency and the boiler, superheater, and economizer efficiency were 90.3 and 94.8 per cent respectively.

New Feed Heater Uses Solid Shell Construction

CONSTRUCTION which is from 30 to 50 per cent heavier, and several refinements of design, mark the points of difference between the new feed water heater, as compared with the old, which has recently been brought out by the Elliott Co., of Pittsburgh, Pa. The additional weight is due to the use of a solid shell construction.

This new type of heater is built in the vertical type in sizes 800 hp. up to 6000 hp. and in the horizontal from 6000 hp. up to any size desired. All heaters



PANS ARE HELD BY SLOTS AND MAY BE REMOVED THROUGH CLEANOUT DOORS

below 800 hp. are of the square type with the central column method of pan support such as has been used in the heaters previously built by this company.

Although the heaters are designed to withstand a working pressure of 15 lb., they are subjected to a hydrostatic test of 25 lb. per sq. in. before leaving the shop. All joints are machined and made steam and water tight by the use of special gaskets.

Internal construction and an exterior view of the heater are shown in the accompanying illustration. It will be noted that the inlet chamber with the overflow feature is integral with the cover. The pans are held in place in slots on supporting bars, and can easily be removed through the cleanout door without the use of special tools or block and tackle. Cleanout and inspection doors are hinged to the shell.

Oil separators are an integral part of the heater, incorporated within the steam inlet opening and the heater is so designed that oily condensate does not contaminate the feed water but is removed through the overflow box. It is equipped with the usual float control and balanced valve to regulate the supply water.

If desired, a cutout valve and overflow trap can be attached. The function of the valve is to shut off the

supply of steam whenever it is necessary to clean the heater and a trap is used to carry away the condensate from the separator and overflow whenever the heater is operating under back pressure.

A. I. E. E. Discusses Many Technical Subjects

MEASUREMENTS OF POWER IN POLYPHASE CIRCUITS, AND VOLT-AMPERE METERS, OF SPECIAL INTEREST TO POWER PLANT MEN AT THE ELEVENTH MIDWINTER CONVENTION

HIGHLY technical subjects occupied the center of the stage in the professional sessions of the Eleventh Midwinter Convention of the American Institute of Electrical Engineers which was held at New York City, Feb. 14 to 17. Thirty-two papers were presented and discussed at seven sessions. Of this number, the majority were of more or less indirect interest to power plant men; but the session arranged for the afternoon of Feb. 16 by the Committee on Instruments and Measurements included papers on the Measurement of Power in Polyphase Circuits and on Volt-Ampere Meters, which will be treated with more detail below.

An outstanding feature of this convention was the joint session with the Chicago section of the Institute which was held on the evening of Feb. 14. For the first time in history, two meetings in separate cities were so fused into one by the employment of direct telephonic communications and loud speakers that papers and discussion presented at both places could be heard with ease in either place and the audiences were essentially one save for the limitation of vision. In his opening remarks, President F. B. Jewett predicted that this barrier would also eventually give way to the progress of electrical science. As was appropriate to the occasion, the two papers presented dealt with the development of public address systems. Presentation of the papers, lantern slides, and discussion, in the two cities was conducted with perfect precision. The formal discussion of the papers was followed by a lecture on Observations on Electric Railway Practice by William B. Potter of the General Electric Co. Mr. Potter has recently returned from an extensive trip in Europe, and his lecture covered observations on electric railways there.

The session on Friday afternoon, to which reference has already been made, included presentation and discussion of a paper by Charles Fortesque of the Westinghouse Electric & Manufacturing Co. under the title Measurement of Power in Polyphase Circuits. This paper, which was supplemented by an appendix giving a theoretical analysis of the measurements required for determination of power in single phase and three phase circuits, gave a statement of conditions which in the opinion of Mr. Fortesque should bring about a change in the basis of measurements and charges for power delivered to customers. He pointed out that present methods of measurement on three-phase systems are on the one hand not equitable to users of symmetrical polyphase machinery, while on the other hand they are too liberal in cases where unsymmetrical loads are encountered. He showed that a generator delivers power only through a medium of positive phase sequence currents, and that any negative phase sequence currents which may appear in the system have been fed back into it in this form as a result of unbalanced loads. This involves a loss in the system which is charged against the consumers having symmetrical machines, in which output is reduced and load power factor is diminished by the negative sequence power.

To obviate this difficulty, Mr. Fortesque proposed that only positive sequence power be charged for as power, and that unbalanced loads should be figured and charged for as unbalanced kv.a., thus properly penalizing this class of load. A generator must deliver (1) true power, (2) reactive power, and (3) power for balancer action, the last factor being of equal importance to the second and equally susceptible of measurement. Devices for making the required measurements are being developed and will be, if anything, simpler than the instruments at present in use.

In discussing Mr. Fortesque's paper, R. D. Evans of the Westinghouse Electric & Manufacturing Co. presented slides showing measuring devices for use on three-phase, three-wire systems, the common principle of which was the use of two elements to take care of positive sequence current and negative sequence current respectively. Mr. Evans emphasized the desirability of more equitable distribution of charges, saying that, for example, it would be better to charge a furnace customer with the energy which he causes to be dissipated in another customer's equipment, and to compensate the other man accordingly.

Prof. V. Karapetoff of Cornell University seemed to think the proposed system too cumbersome to be practicable, saying that it would be difficult to get Public Service Commissions and business men to agree to it, as vector analysis would be difficult to explain to the customer's satisfaction.

E. P. Peck of the Utica Gas and Electric Co. said that you cannot base a rate upon anything not understood by the customer, and that circuits may be commercially balanced by checking them from time to time. Investments in transmission and distribution equipment, voltage, variations in load factor, and other items being left out of account in making the rates, it seemed inadvisable to him to consider less important elements.

In reply to the criticisms of Messrs. Karapetoff and Peck, Mr. Fortesque said that the Public Service Commissions and the business men could be relied upon to appreciate facts when necessary, citing the common prevalence of radio terms as an example of general comprehension of technical matters. He said that even if the methods advocated did not come into use, the principles could be employed in rate making.

In a short paper on Volt-Ampere Meters, R. C. Fryer, Superintendent of Electric Meters for the Union Gas and Electric Co. of Cincinnati, Ohio, gave a summary of progress in development and use of these instruments, with a classification and description of the principal types. The classification follows:

(1) Proper phase relation type meters.	Full Range	The Bodi Meter (Westinghouse)	
		The Angus Meter (Esterline-Angus)	
	Fixed Range	General Electric Meter	
		The Lincoln Meter	
(2) Resultant type	Full Range Indicating	The Lincoln Meter	
		The Sangamo Meter	
	Full Range Integrating	The Sperti-Blecksmith Meter	
		(Westinghouse)	

Mr. Fryer referred to a recent report of the Subcommittee on Power Factor and kv.a. of the National Electric Light Association Meter Committee showing that of 418 utilities in this country and Canada, 59 have clauses in their contracts relating to charges to be made to customers with low power factor, and said that considerable advance has been made in the adoption of synchronous machinery, the use of kv.a. meters, and other corrective measures.

Discussion of Mr. Fryer's paper was in the main very favorable to it. P. A. Borden, of the Hydro-Electric Power Commission Laboratories, Toronto, Canada, referred to the increasing use of kv.a. meters in Canada, making special reference to the Lincoln and Sangamo type. In closing, Mr. Fryer said that considerable progress has been made in solving the relation of power factor to rates, and that the meter manufacturers stood ready with the proper apparatus. He said, however, that the general adoption of a new system of rate setting is bound to be slow, largely on account of the many contracts which have been made on 5-year or 10-year bases.

Attendance at the convention, as well as at the individual sessions, was good. The usual social features were provided, including a smoker, a dinner dance and trips of inspection to places of interest in the metropolitan district. Saturday morning, the final day of the convention, was given over entirely to such visits.

Heating and Ventilating Engineers Hold Annual Meeting

THIS YEAR the mid-winter convention of the American Society of Heating and Ventilating Engineers was held Jan. 23 to 26, in New York and Washington. The first meeting, Tuesday the 23rd, at the Engineering Societies' Building in New York, was a business session at which reports of the various committees were presented and the results of the annual election announced. The election followed the recommendations of the nominating committee in every respect. H. P. Gant, first vice-president for 1922, was elected president; Homer Addams, treasurer for 1922, was elected first vice-president; E. E. McNair, second vice-president, and William H. Driscoll, treasurer.

Wednesday started the technical sections at Washington with an all day session at the U. S. Bureau of Standards. Papers pertaining to current work on heating and ventilating were read. They were "Heat Transmission of Building Structures," by M. S. Van Dusen; "Testing of Amemometers," by O. J. Hodge; "Tests of Radiator Return Line Valves," by W. F. Stutz, and "Fire Tests of Structural Materials," by S. H. Ingberg. The afternoon was turned over to an inspection of the laboratories of the Bureau.

At the evening session at the convention headquarters, reports of the technical committees were submitted and several papers describing features of certain installations in Washington were read. These were: "Forced Circulation Hot-Water Heating System in the National Museum," by C. R. Denmark; "Heating and Ventilating System in the Bureau of Engraving and Printing," by N. S. Thompson, and "Fan Blast Heating in the Gun Shop of the U. S. Navy Yard," by M. S. Cooley.

In the first of these papers, the system described is a one-pipe system, the unusual feature of which is the manner in which the radiator connections are made. Two connections are provided on the same end of the radiator, the supply at the top and the return at the bottom. Long turn bends are used to provide sufficient water to each unit. There are 130 risers supplying some 73,000 sq. ft. of direct radiation. In addition there is also provided about 2500 sq. ft. of indirect radiation. The water is heated in a surface condenser by exhaust steam after it has passed through an open feed water heater. Circulation is maintained by a motor driven volute pump capable of handling 170,000 gal. per hr.

For heating the building of the Bureau of Engraving and Printing, a two-pipe vapor system is used, supplying about 55,000 sq. ft. of direct radiation. In addition, a hot blast system having the equivalent of 66,000 sq. ft. of direct radiation is installed to provide adequate ventilation.

Thursday there was the session on research in the assembly room of the Bureau of Standards. The papers presented here were, first, the report of the research committee and then "The Physiological Reactions of Humans to High Temperatures and Humidities," by W. J. McConnell and F. C. Houghton; "Equal Comfort Lines for Still Air Conditions," by F. C. Highton and P. C. Yagloglou; "The Anderson and Armspach Dust Determinator," by Margard Ingels, and "Capacities of Steam Heating Risers as Affected by Critical Velocities of Steam and Condensate Mixtures," by F. C. Houghton and L. Ebin.

This last paper was a complete report of the work thus far accomplished by the research laboratory. It constitutes a verification of the report presented at the summer session in Detroit in June, 1922, when a few tentative conclusions were drawn. Header pressures of from 0.30 to 0.40 in. of water were used and risers from 1-in. to 2-in. size, and it was found that the critical velocity for all tests ranging from very rough to very smooth pipes varied from 225 to 29 ft. per sec., with an average of about 25 ft. per sec. It was also found that within the limits of experimental error the critical velocity is independent of the pipe size. The question of the effect of orifices on capacity was also given consideration and the conclusion was reached that the maximum capacity of a pipe was determined by the minimum sectional area at any point. In view of this fact it was recommended that all pipe ends be seamed on the inside after it has been cut for a joint, because the burr left by the cutter may reduce the capacity by as much as 30 per cent.

Both morning and afternoon sessions on Friday were at the convention headquarters. Papers read at the morning session on heating were "Comments on Warm Air Furnace Installations," by V. T. Gibbin and J. K. Chew; the report of the code committee for warm air furnace installations; and "Humidity Requirements for Residences," by A. P. Kratz.

At the ventilation session in the afternoon, the papers presented were "Modern Tendencies of Ventilation Practice," by G. F. Palmer; report of the New York State Commission on Ventilation; "Comparative Tests of Roof Ventilators," by F. B. Rouley; and "Wind Tunnel Tests of Roof Ventilators," by H. L. Dryden.

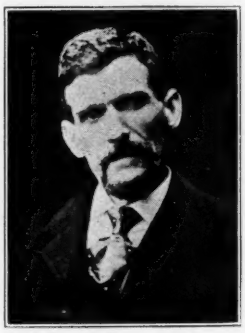
In his paper on ventilation tendencies, Dr. Palmer points out that high CO_2 content in the atmosphere does not in itself mean poor ventilation. The hurtful constitutent is the organic matter that is present. The CO_2 standard is simply used as an indicator of the amount of other impurities in the air, and probably for this reason the belief has been established that the CO_2 is the harmful element when such is really not the case. Modern requirements for good ventilation are that:

1. The air should be cool.
2. It should be in gentle motion and its temperature should fluctuate slightly momentarily.
3. It should be free of offensive odors, poisonous and offensive fumes and large amounts of dust.

Temperature and air movement take precedence over chemical and respiratory elements. It is noteworthy that no CO_2 standard is given, nor is any minimum volume of air recommended.

Death Closes Career of David Cochrane

ON JANUARY 24 the death of David Cochrane, the inventor, designer and first builder of the open feed water heater which bears his name, closed the career of a man whose ideas have resulted in the conservation of millions of tons of coal a year in the United States and elsewhere. Mr. Cochrane was born in Sawkey, Clackmannanshire, Scotland, in 1850, and in his early years worked as a pattern-maker on the Clyde. In 1879 he came to the United States, where he entered the employment of Ferris & Miles, but, shortly afterward went with the Harrison Safety Boiler Works, then the builders of a sectional cast-iron boiler. His open heater, brought out in 1883, was specifically designed to protect boilers from the effects of cold, unpurified feed water and was itself the first to be built of cast-iron plates, to avoid corrosion. Mr. Cochrane was also the first to design a successful oil separator, a heater and receiver, and other appliances which have since become standard practice. He was distinguished by great common-sense in engineering matters and had a peculiar capacity for winnowing the wheat from the chaff and for simplifying construction. He was frequently consulted concerning the design of steam plants, and his great contribution to steam engineering consisted in focusing attention upon the more efficient utilization of exhaust steam for heating buildings and for heating and purifying water to be used for feeding boilers and for industrial purposes. As early as 1894, he advocated the withdrawal of steam in course of expansion for feed heating and similar purposes, thus anticipating the present day movement to provide all large turbines with bleeder connections.



DIAMONDS are chunks of coal that stuck to their job. —Forbes Magazine.

News Notes

SUPPORT OF the A. S. M. E., through its Forest Products Division, was pledged by President John Lyle Harrington to the American Wood Preservers' Association in securing legislation for the preservation and intelligent use of present standing timber and the propagation of our forests. W. H. Grady, member of the A. S. M. E. from Louisville, Ky., has been president of the American Wood Preservers' Association for the past year.

J. L. STANNARD, an engineer of San Francisco, was recently retained by the City Council of Tacoma, Wash., as engineer in chief for the construction of the Lake Cushman power project. The project, which will cost about $6,000,000, will soon be begun. It is intended to add about 90,000 hp. to the present facilities of the municipal light and power department.

ONE OF THE attractive features of the Pacific Coast Regional Meeting of the A. S. M. E., scheduled for Los Angeles April 16-18, is a visit to the solar observatory on Mt. Wilson. The lecture and demonstration of the 100-in. telescope there will be of considerable technical interest to engineers attending the three-day meeting.

NUMEROUS REQUESTS for the Rules for Fuel Conservation in Homes, prepared and issued in printed form by the Fuels Division of the A. S. M. E., have been received. The Rhode Island fuel administrator recently ordered 10,000 copies of the rules and the public utilities commission of the District of Columbia ordered 5000 copies.

C. A. ANDERSON JR. has just been appointed general sales manager of the Pittsburgh Valve, Foundry & Construction Co., Pittsburgh, Pa., succeeding James D. Robertson, who resigned Feb. 1, due to ill health. Mr. Anderson was formerly district manager of the Philadelphia office of this company.

PAUL T. BUCKLER, for 14 yr. with the Detroit Stoker Co. as manager, successively of the Pittsburgh, Cleveland and New York offices, is now with the Power Specialty Co., for whom he is assisting the New York office in the sale of Foster superheaters and economizers.

THEODORE B. PARKER, who was formerly assistant hydraulic engineer for the Electric Bond & Share Co., and who filled a similar position with the Utah Power & Light Co. prior to that, has entered the Hydraulic Division of Stone & Webster, Inc., of Boston, Mass.

CLOYD M. CHAPMAN has become affiliated with Dwight P. Robinson & Co. as consulting materials engineer. Mr. Chapman has been active in the work of the American Society of Testing Materials and the American Concrete Institute.

ALBERT W. HONYWILL JR. has severed his connections with the Terry Steam Turbine Co., at Hartford, Conn., to take up new duties as assistant to the president of the Diamond Power Specialty Corporation, of Detroit.

INFORMATION has just been received to the effect that the Dean Bros. Steam Pump Works, of Indianapolis, Ind., has changed its name to Dean Bros. Co.

MAJOR J. F. BELL, district engineer at Pittsburgh, held hearings Jan. 30 at Morgantown, W. Va., on the application of the West Penn Co. to construct a series of dams and to install hydroelectric plants along the

Cheat River and the Big Sandy, in West Virginia and Southern Pennsylvania. The company has already invested several million dollars on these projects, which, when completed, will comprise the largest group of power plants in these states. The first proposed dam is to be near Point Marion, Pa., and will be 80 ft. high. Another dam, on the Big Sandy, to be 200 ft. high will flood over 6000 acres.

THE DEATH of John B. McGowan, Superintendent of the Cunard Building, 25 Broadway, New York City, occurred on Jan. 31. Aside from his business activities, Mr. McGowan was interested in various activities for the benefit of local engineers, chief among which was his work for the National Association of Stationary Engineers, of which he was one of the leaders in the metropolitan district.

NINE APPLICATIONS for permit or license under the Federal Water Power Act were filed with the Commission during the three weeks' period ended Feb. 10, 1923, making a total of 387 applications received to that date. Among these applications was one by the American Super-Power Corporation which applied for a preliminary permit for two power dams in the St. Lawrence River, one near Washington, and the second near Massena, N. Y. The capacity of the two projects is estimated at 1,350,000 hp. The applicant proposes to market the power by a system connecting with power centers in Boston, New York, Philadelphia, Baltimore and Washington.

PHILADELPHIA ELECTRIC CO. is to award a contract for the addition to its present power plant in Philadelphia. Provision is to be made for housing three modern type 30,000-kv.a. units. Only two units are to be constructed at present. The cost is estimated at from $6,500,000 to over $7,000,000. Stone & Webster Co., who built the Beach St. power station in Philadelphia, are working on the foundation now. Walter K. Johnson, senior vice-president of the Philadelphia Electric Co., says that the increased demands for power made necessary the immediate construction of two of these new units. The total increased load of 60,000 kw. handled by the new stations will give a total steam turbine power generating capacity of 150,000 kv.a. in Philadelphia. New Commercial, domestic and railroad consumers of power are causing this growth. When the third unit is built, the company will have the equivalent of nearly 200,000 hp. in all stations.

Books and Catalogs

ENGINEERING INSPECTION, by E. A. Allcut and Chas. J. King; 6½ by 9¾ in., 187 pages, 161 illustrations, cloth; New York, 1922.

Although much descriptive material has already been written on the details of the various inspection methods used in engineering works, the object of this work, as explained by the authors, is to present in a compact and convenient form, a description of the principles involved in the inspection of an engineering job from raw material to the finished product.

Examples given are for the purpose of illustrating different principles of inspection and measurement in common use. Mechanical engineering only is described. Subjects dealt with are briefly, objects of inspection; storage of material; material tests and specifications; inspection of raw, partly finished and finished material; measuring instruments; shop inspection; final tests, and repairs. There is also included a chapter on "the human element" and its effect on inspection.

BELT CONVEYORS AND BELT ELEVATORS, by Frederic V. Hetzel; 6 by 9 in., 333 pages, 291 illustrations, cloth; New York, 1922.

Since the development of material handling equipment and the increasing number of applications has been so rapid during the past few years, it is not surprising to find a book of 333 pages which deals with a specialized phase of the subject, such as this work on belt conveying. The author covers the subject in a comprehensive manner, taking up such points as types of belts, driving the belt, tension and take-up devices, loading, discharging, special uses, and the care and operation of such equipment. The section on belt elevators is also covered from the design, installation and operating viewpoints.

SMALL SINGLE-STAGE centrifugal pumps for motor or belt drive are described in a leaflet and in an instruction manual issued by the De Laval Steam Turbine Co., of Trenton, N. J. These pumps are made in 1½ and 2-in. sizes, and are designed for capacities ranging from 5 gal. per min. against 10 ft. head up to 130 gal. per min. against 150 ft. head. The publications give complete tables and instructions for selecting pumps for different conditions, and explain how to determine the proper speeds and how to select piping, valves, fittings, and driving pulley or motor to secure an efficient and satisfactory installation.

"APPLYING SCIENCE TO INHIBIT RUST" is the title given to a 32-page booklet issued by the Dearborn Chemical Co., of Chicago. It treats of rust as a disease of metal and the scientific method of removing and preventing rust by the use of No-Ox-Id. This product, which has been developed to overcome rusting from air contact and also the tendency for surface rust underneath the coating, is furnished in various consistencies for different purposes, and as shown in the booklet can be applied either by brushing or spraying as most convenient.

THE PRINCIPAL CHARACTERISTICS of several great rapid transit systems from an electrical engineering viewpoint are presented in Bulletin 44,018 issued by the General Electric Co.

The facilities for power production, transformation, transmission and utilization are outlined briefly for each of the systems in the cities of Boston, Chicago, New York and Philadelphia.

IN THE FEBRUARY number of the Walworth Log, the Walworth Manufacturing Co., of Boston, Mass., tells about the acquisition of the Herman Rivitz Co., of Cleveland, Ohio, by the Walworth Ohio Co. The warehouse facilities of the Rivitz company will be used in the distribution of Walworth products through Ohio and western Pennsylvania.

COLONIAL SUPPLY CO., of Pittsburgh, Pa., in its new catalog covering valves has departed somewhat from the usual precedents in that the valves manufactured by a number of different manufacturers are grouped under one cover.